

# Obesogenic environments as major determinants of a disease: It is time to re-shape our cities

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## Abstract

Obesity rates are increasing in almost all high- and low-income countries, and population-based approaches are necessary to reverse this trend. The current global efforts are focused on identifying the root causes of obesity and developing effective methods for early diagnosis, screening, treatment, and long-term management, both at an individual and health system level. However, there is a relative lack of effective options for early diagnosis, treatment, and long-term management, which means that population-based strategies are also needed. These strategies involve conceptual shifts towards community- and environment-focused approaches. This review aimed to provide evidence on how environmental factors contribute to the risk of obesity and how reshaping cities can help slow down obesity prevalence rates and improve long-term management.

## KEYWORDS

environments, obesity, obesogens, public health, public policies

## 1 | INTRODUCTION

Since the mid-1970s, obesity prevalence rates have rapidly and steadily grown, and globally, they have almost tripled to date.<sup>1</sup> The numerous efforts made towards the primary prevention of obesity at

the population level have not had the desired effect, and the prevalence of the disease continues to grow, suggesting that perhaps there are some aspects related to its development that are currently not being adequately addressed and for which appropriate solutions are not being planned.

**Abbreviations:** ALAN, artificial light at night; BMI, body mass index; CARDIA, coronary artery risk development in young adult.

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There is growing evidence on the interaction between the urban physical and social environment on the biology of obesity, although the evidence is incomplete and comes from a limited range of countries.<sup>2,3</sup> Indeed, although it has long been established that nutritional intake and physical activity are both very important elements in general health promotion for all dietary-related chronic diseases as well as part of therapeutic treatments for obesity, it should be taken into account that access can be heavily impacted by the environment, socioeconomic level, psychology, ethnicity, and geographic location of the at-risk population and those already living with obesity.<sup>2,3</sup>

The presence of walkable neighborhoods allows people to walk or bicycle to the workplace and amenities such as shopping centres, parks, schools, and entertainment centers, allowing less weight to be gained over the years.<sup>4</sup> There is also evidence that areas with increased access to fast food outlets and convenience stores offering processed food with high sugar and fat content have a higher prevalence of obesity.<sup>5</sup> Restaurants are another key point for new anti-obesity policies. Indeed, the presence of healthy-trained chefs should be ensured in order to tailor meals according to the health needs of people living with obesity and obesity-related comorbidities. Restaurant menu labelling (by calories and nutrients) is also necessary to promote a healthy, viable choice.<sup>6</sup> The time at which dinner is served should be fixed not too late in the day. In fact, there is evidence that late dinner could result in detrimental metabolic effects, encouraging the onset of obesity.<sup>7</sup> In addition, attention must be paid to the food supply chain.

Recent medical evidence has provided more convincing data about the relationship between certain chemicals and the increased risk of developing obesity.<sup>8</sup> Endocrine disrupting chemicals, which imitate natural hormones and interfere with the body's own hormones, are particularly problematic.<sup>9</sup> A subset of these chemicals, called obesogens, have been found to cause metabolic disruptions that lead to increased fat storage. Obesogens impact the functioning of different systems, including adipose tissue and the gut microbiome, and affect the metabolic system through multiple pathways. Furthermore, obesogenic compounds have been shown to cause metabolic disturbances in future generations, even after exposure.<sup>9</sup> Food is the primary source of obesogens, which can be present naturally or as environmental chemicals in processed foods in high amounts as contaminants or additives.<sup>8</sup>

Finally, outdoor Artificial Light at Night (ALAN) is another target we should focus on. Indeed, in a sample of 239,781 men and women (aged 50–71) from the NIH-AARP Diet and Health Study who didn't suffer from obesity at baseline (1995–1996), outdoor ALAN exposure estimated from satellite imagery at baseline was associated with higher odds of developing obesity over 10 years.<sup>10</sup>

Based on this evidence, we reviewed the current literature, and we identified the urban targets on which to act to make a city anti-obesogenic.

## 2 | GREEN AREAS AND WALKABLE NEIGHBORHOODS

Due to increasing urbanisation, people are faced with the prospect of living in environments with few green areas and walkable neighborhoods. Increasing importance has been attached to understanding how the environment in which people live can help anti-obesity behaviour and policies. This shift means a departure from a model that primarily emphasises individual responsibility and instead highlights the influence of environments that promote obesity, known as '*obesogenic environments*'.

It is now known that green areas could contribute to improving public health.<sup>11,12</sup> In this regard, an empirical study of 250,782 Dutch research participants who filled out a self-administered form on socio-demographic background and perceived general health found a positive association between the percentage of aggregate green areas (urban green, agricultural green, forests, and natural conservation areas) (within 3 km around the postcode coordinates) in people's living environment and perceived general health.<sup>12</sup> The same authors then analysed morbidity data from the electronic medical records of 345,143 research participants. They found that the annual prevalence rate of 15 of 24 disease groups (including coronary heart disease, musculoskeletal disorders, depression, and anxiety) was lower in living environments with more green areas within a 1-km radius.<sup>11</sup>

Neighborhoods are a key setting for active recreation. The walking network (including footpaths and trails), cycling routes (roads and bike paths), open leisure areas (like parks), and organised recreational facilities (such as sports fields or centers) make up the urban environment. A large body of research has shown the correlation between urban features, land usage, and obesity rates. Of note, a seminal study with 10,878 participants revealed a connection between areas with diverse land use (residential, commercial, offices, and institutions) and a lower risk of obesity, possibly due to greater opportunities for outdoor physical activity.<sup>13</sup> In contrast, another study of 104,084 respondents that focused on urban planning found that urban sprawl was associated with an increased risk of overweight or obesity.<sup>14</sup> Many other authors have found similar results.<sup>15–17</sup> In general, these studies emphasise the role of the walkability of spaces in urban areas and neighborhoods in encouraging outdoor activities for more than just recreational purposes.<sup>15–17</sup> The presence of recreational activities in urban areas is often positively associated with greater physical activity and a healthier weight.<sup>18–20</sup> An extensive literature review ( $n = 10$  studies) on this topic emphasised that the walkability of spaces is one of the key factors in preventing obesity.<sup>21</sup> Furthermore they emphasised the ability of these results to be generalised to different geographical scales or land-use measurement methods. The general conclusion of the literature is that a built environment that offers more opportunities for outdoor activity reduces average weight and the propensity to suffer from overweight or obesity.<sup>21</sup> It is therefore clear that adopting a healthy lifestyle to manage obesity also involves living in

environments that favour physical activity. Several studies have shown in this regard that the availability of green areas significantly increases the likelihood of physical activity.<sup>12,19,22</sup> For example, data from the 2005 Bristol Quality of Life in your Neighbourhood survey ( $n = 6821$  adults) first showed that the frequency of use of green areas decreases with increasing distance.<sup>22</sup> Secondly, the study also found that respondents who lived closer to the type of green space classified as a 'formal park' were more likely to achieve the physical activity recommendation and less likely to suffer from overweight or obesity. The findings suggest that the provision of good access to green areas in urban spaces may help promote population physical activity.<sup>22</sup>

Furthermore, the lack of green areas and the high industrialization of modern cities can lead to an increase in air pollution, as plants and trees play a crucial role in purifying the air.<sup>23</sup> As reported by the World Health Organization, air pollution is now considered a major threat to global health and a major risk factor for non-communicable diseases.<sup>24</sup> Interestingly, the accumulation of epidemiological studies has shown that overweight and obesity can be partially attributed to environmental exposure to air pollution.<sup>25</sup> The precise link between exposure to air pollution and obesity is currently unclear, but recent studies have shed light on key mechanisms. Inhaling pollutants triggers lung inflammation, releasing inflammatory cytokines and oxidative stress molecules into the bloodstream, with multi-organ consequences. Particulate matter, such as particulate matter and ultrafine particles, can enter the bloodstream directly, damaging secondary organs. In addition, air pollution alters the nervous and endocrine systems. These processes culminate in metabolic disorders and obesity. Finally, epigenetic modifications, both early and later in life, play a role in this process by activating downstream signaling pathways.<sup>25</sup>

Green areas are also believed to be therapeutic and able to mitigate the effects of stress and mental fatigue,<sup>26–28</sup> which may be related to weight gain.<sup>29,30</sup> The stress-reducing property of natural environments may derive from people's willingness to respond positively to nature, as natural views attract attention, and thus negative thoughts and emotions can be blocked and replaced by positive ones.<sup>31</sup> Further, other types of green areas, like cropland, could offer significant public health benefits through providing opportunities to consume locally grown foods, which are often fresh and healthy, and to engage the local population in physically demanding jobs (e.g., the planting and harvesting of fruits or vegetables).<sup>32</sup>

- **Key messages.** The urban characteristics of the neighbourhood in which one lives are closely involved not only in the development but also in the prevention of obesity. While it is difficult to increase the amount of open recreational space within an existing built environment, protecting the loss of such spaces requires a strong culture of 'green preservation' within local governments against continuing commercial pressures. Local governments have at their disposal a wide range of measures to improve recreational spaces, such as extending pedestrian and bicycle paths, adding sports facilities, and increasing green areas.

### 3 | TRANSPORT SECTOR

This sector involves government at all levels, the private sector (such as the automobile industry and property developers), non-governmental organisations and professional groups (such as town planners).

The transport sector provides a vital and necessary link not only for access to basic services, such as grocery shops and supermarkets, but also for continuous health care and access to treatment, particularly for people with chronic diseases such as obesity. The treatment of chronic diseases requires medical checkups, access to medication, and changes in treatment plans to provide evidence-based care. However, in the absence of appropriate transport, delays in clinical interventions occur. These delays in care can lead to a lack of appropriate medical treatment, an exacerbation of the chronic disease, or unmet health needs, which can accumulate and worsen health outcomes. Moreover, it is not only a matter of the absence or presence of a good public transport network but also their adequacy to accommodate people with obesity. Indeed, among the most frequent stigmatising situations experienced by people with obesity are physical barriers (e.g., chairs that are too small),<sup>33</sup> which ultimately lead to the avoidance of their use.

In addition, the impact of land use and transport systems on physical activity levels has recently been examined.<sup>34</sup> Within the built environment, land development patterns (e.g., public transport and walking vs. cars) and transport investment patterns (e.g., public transport, walking and cycling, vs. highways) are closely interrelated and have a profound effect on physical activity levels. The utilization of public transportation, which frequently involves short walks, can be classified as 'active transport' when combined with walking and cycling. In car-dominated societies, only a minority of trips are undertaken by walking or cycling, with most of them for recreational purposes rather than for transport to a destination, whereas in several European countries (in particular the Netherlands), walking and cycling trips equal or exceed car trips.<sup>35</sup> This, in part, probably explains some of the observed differences in obesity prevalence rates between countries (in 2019, obesity prevalence rates ranged from 3.5% in Bangladesh to 32% in the USA).<sup>36</sup> In a study conducted in China, where cycling is still the most common form of transport, the purchase of a motor vehicle doubles the odds of developing obesity.<sup>37</sup>

Influencing attitudes towards active transport is another important aspect of achieving changes in transport use patterns, because attitudes can be as strongly associated with car transport as with land-use characteristics. If the environment is conducive to active transport, a mass marketing approach seems to be able to influence behaviour in the long term. In a pilot study in Perth, Australia, simply marketing active transport options to every household in a suburb led to a 14% reduction in car travel and an increase in the use of walking, cycling, and public transport.<sup>38</sup> The changes were most pronounced for short trips and were maintained for 2 years.<sup>38</sup> Again, modest changes in transport modes multiplied by large volumes of short trips, where active transport is an option,

may lead to a significant increase in physical activity for the population.

- **Key messages.** The transport sector is the key to facilitating accessibility to basic services and essential health services for people living with obesity. Since much of the current built environment is car-oriented, interventions will need to 'retrofit' existing communities and direct new urban and suburban developments to make them more conducive to physical activity. Interventions could include the promotion of pedestrian- and bicycle-friendly street design, increased investment in public transport, and the designation of streets and areas in central business districts as car-free.

## 4 | FOOD SECTOR

### 4.1 | Fast food and restaurants

Although what we eat is usually considered a lifestyle choice, research suggests that both the type and amount of food and drink we consume are influenced to a surprisingly large extent by environmental cues.<sup>39</sup> This is the case at the community level. Efforts to improve nutrition and stem the obesity epidemic have increasingly focused on policy approaches to improve the community food environment, for example, to attract supermarkets where they do not exist and to help smaller markets offer fresh produce. Another strategy has been to reduce, or at least not increase, the density of fast-food restaurants and convenience stores, particularly in food-poor neighborhoods, often referred to as 'food deserts'.

The evidence supporting these strategies is limited but growing. So far, most studies have been cross-sectional, making it difficult to identify more than intriguing hypotheses for further research. The Coronary Artery Risk Development in Young Adults study was an exception.<sup>40</sup> It was a carefully designed and executed cohort study examining the relationship between proximity to supermarkets, grocery shops, and fast food and the eating practices of 5115 young adults in 4 cities. The study utilised a series of validated and relatively detailed measures of food intake at different points in time, linked to longitudinal geographic data on local food environments within pre-defined distances from each subject's residence. In addition, the analysis took into account a number of potentially confounding factors, including individual socio-demographic characteristics and neighbourhood poverty. Research participant retention during the 15-year follow-up period was relatively high, despite the high level of residential mobility. The most significant finding was the association between the availability of fast food and the increase in food consumption.<sup>40</sup> This finding has important implications, given the well-documented link between frequent consumption of fast food, poor diet quality, and an increased risk of obesity.<sup>41</sup> Results like these provide some support for zoning efforts to reduce the density of fast-food restaurants in low-income communities.<sup>42</sup> For example, in Los

Angeles, a moratorium on new fast-food restaurants was established in 2008 in a low-income area of the city. Although the potential of this policy as a stand-alone intervention to reduce obesity prevalence has been questioned, it also serves as a model for other municipalities when accompanied by more comprehensive efforts to improve local food environments.<sup>42</sup>

### 4.2 | Healthy menus

Given the great public desire for the convenience offered by fast-food restaurants, another important approach could be to use voluntary incentives or regulatory interventions to promote *healthier* dishes (more balanced in terms of macro- and micronutrients) and smaller portions in these restaurants. The recent introduction of mandatory menu labelling in large fast-food chains is one such example, generating a potential incentive for restaurant chains to reformulate their menu offerings towards lower-calorie options. A review ( $n = 15$  studies) and meta-analysis ( $n = 12$  studies) assessed the effect of menu labelling regarding changes in energy consumed, ordered or selected in both real-world and experimental settings.<sup>43</sup> Overall, nine studies showed statistically significant reductions in energy consumed, ordered, or selected. Three articles reported no effect of menu labelling. According to the meta-analysis, the implementation of menu labelling resulted in significant effects, with an average reduction of approximately 100 kcal in overall energy consumed and an average decrease of approximately 78 kcal in the energy ordered in real-world settings.<sup>43</sup> However, results on the potential of the labelling menu are still scarce and not entirely concordant. Moreover, it is now well understood that to prevent and treat obesity, it is no longer sufficient to rely on calories in and out but rather to pay attention to the quality of the calorie's intake. Promoting more nutrient-balanced choices is therefore of greater interest. Furthermore, describing more nutritious menu options in less attractive terms may perpetuate the belief that healthy foods are not tasty or indulgent and may undermine customers' choice of healthier dining options. From a public health perspective, incorporating more appealing descriptive language to increase the attractiveness of nutritious foods may be one avenue for improving dietary health.

Because of increasing welfare and the employed workforce, the number of people who need to eat at least one meal away from home is increasing. Consequently, it seems plausible that restaurants could play another role in improving the nutrition of the population, and since they are directly involved in the preparation and supply of food, chefs could be key figures in the restructuring towards an anti-obesogenic city. In a preliminary study on the key factors and constraints influencing chefs' attitudes and beliefs towards offering healthy menus, questionnaires were administered to 71 chefs.<sup>44</sup> Most of the respondents practiced the principles of healthy eating, either through cooking practices or by modifying ingredients. Although the chefs felt that they had a good knowledge of nutrition, in reality, they had no more than the average person, which could be

explained by the lack of education and training in nutrition. Therefore, it is possible to question the ability of chefs to construct nutritionally correct menus and to cook healthily. Furthermore, the results showed that a large percentage favoured the idea of nutrition training.<sup>44</sup> It could therefore be assumed that the provision of short courses, which are an important feature of food safety approaches and which have successfully increased awareness and understanding of food hygiene principles, could also be applied to nutrition and healthy eating to train 'health chefs', that is, chefs specialised in providing healthier alternatives on menus.

### 4.3 | Meal timing

There is observational evidence that eating at unconventional hours, in particular eating late in the day, is associated with a greater risk of an adverse metabolic profile and obesity. Rodent studies support the notion that eating during the biological night has negative effects on the regulation of body fat (subsequent references). Nocturnal mice (more active and consuming most of their calories during the dark phase when maintained on a light-dark cycle) fed during their light cycle gain more weight and tend to have a greater percent body fat despite similar energy intakes and physical activity as mice fed during the dark cycle.<sup>45</sup> Another study showed similar results, finding greater weight gain as a result of increased food intake and reduced fat oxidation in mice fed only during the light cycle.<sup>46</sup> In this regard, a recent randomized, controlled, crossover study investigated the effects of late versus early eating in 18 adults with overweight or obesity, strictly controlling nutrient intake, physical activity, sleep, and light exposure.<sup>47</sup> Among the results obtained, eating late (meals eaten late in the wake episode) altered appetite-regulating hormones, increased hunger, reduced energy expenditure during wakefulness, and altered pathways involved in lipid metabolism, resulting in decreased lipolysis and increased adipogenesis. These results show convergent mechanisms by which delayed food consumption can lead to a positive energy balance and an increased risk of obesity.<sup>47</sup>

### 4.4 | Nutritional transition

The problem of unhealthy eating habits goes beyond the local infrastructure and probably originates in a broader phenomenon known as nutritional transition. Nutritional transition refers to the significant change in dietary patterns globally.<sup>48</sup> This transition is characterised by an increase in the consumption of ultra-processed foods (UPF). Initially, UPFs represented a relatively small portion of diets, but their prevalence is rapidly expanding, reflecting a worldwide shift towards more processed and convenience-based diets. This nutritional transition is driven by several key factors. First, as countries grow economically and become more prosperous, there is a corresponding increase in the availability and consumption of UPF. This phenomenon is more pronounced in regions such as Australasia, North America, Europe, and Latin America, which have higher income

levels. However, it is important to note that this trend is not limited to wealthy regions; it is also taking hold in Asia, the Middle East, and Africa, where economic development and globalisation are increasing. This change in food patterns is closely linked to the industrialisation of food systems, technological advances, and globalisation, which have led to the proliferation of transnational food companies. These companies often prioritise profit over nutrition, leading to increased availability and marketing of UPF.<sup>48</sup> In this regard, it is well known that higher purchases or consumption of UPF have been associated with overweight/obesity.<sup>49</sup>

- **Key messages.** As can be easily guessed, the food sector contributes significantly to the obesity problem. There are numerous strategies that can be implemented in this environment, such as reducing the density of fast-food restaurants, providing menu labelling, training 'health chefs', and finally reshaping the opening and closing times of restaurants, aligning them with normal human circadian biology, and avoiding allowing meals during the later hours of the day.

## 5 | URBAN LIGHTS

This process of urbanisation, the growth of cities in terms of both population and physical size, began several centuries ago and was triggered by the commercialisation of electric light in 1879 by Thomas Edison during the Industrial Revolution. Electric light made it possible to extend lighting during all hours of the day, switching from natural lighting in the daytime to artificial lighting at night, with unexpected effects on human health that are still being studied today.

Scientific studies suggest the overuse of ALAN is the main source of light pollution.<sup>50</sup> In particular, frequent exposure to excessive ALAN emitted by residential areas and road illumination. And non-stop economic activity has been recognized as one of the major and novel risk factors for obesity, with trends in nocturnal light pollution paralleling demographic trends in obesity.<sup>51</sup> In this regard, a study investigated the strength of the association between ALAN and country-wide overweight and obesity rates, controlling for several confounding variables.<sup>52</sup> The research uncovered that ALAN was a predictor that was both statistically significant and positively correlated with overweight and obesity. When considered alongside other factors, it contributed to explaining roughly 70% of the differences in overweight and obesity rates among males and females across over 80 countries globally. Artificial Light at Night may influence the biology of obesity by suppressing melatonin production and disrupting daily circadian rhythms, resulting in physiological or behavioural changes in the human body, and may thus become a driving force behind the worldwide overweight and obesity pandemic.<sup>52</sup> Circadian disruption refers to the temporal organisation of 24-h biological rhythms that optimise our body's metabolic functioning; it is also called 'chronodisruption'.<sup>53</sup> Artificial light during the 'biological night' disturbs the circadian system, alters sleep activity, suppresses melatonin production, and deregulates circadian genes linked to

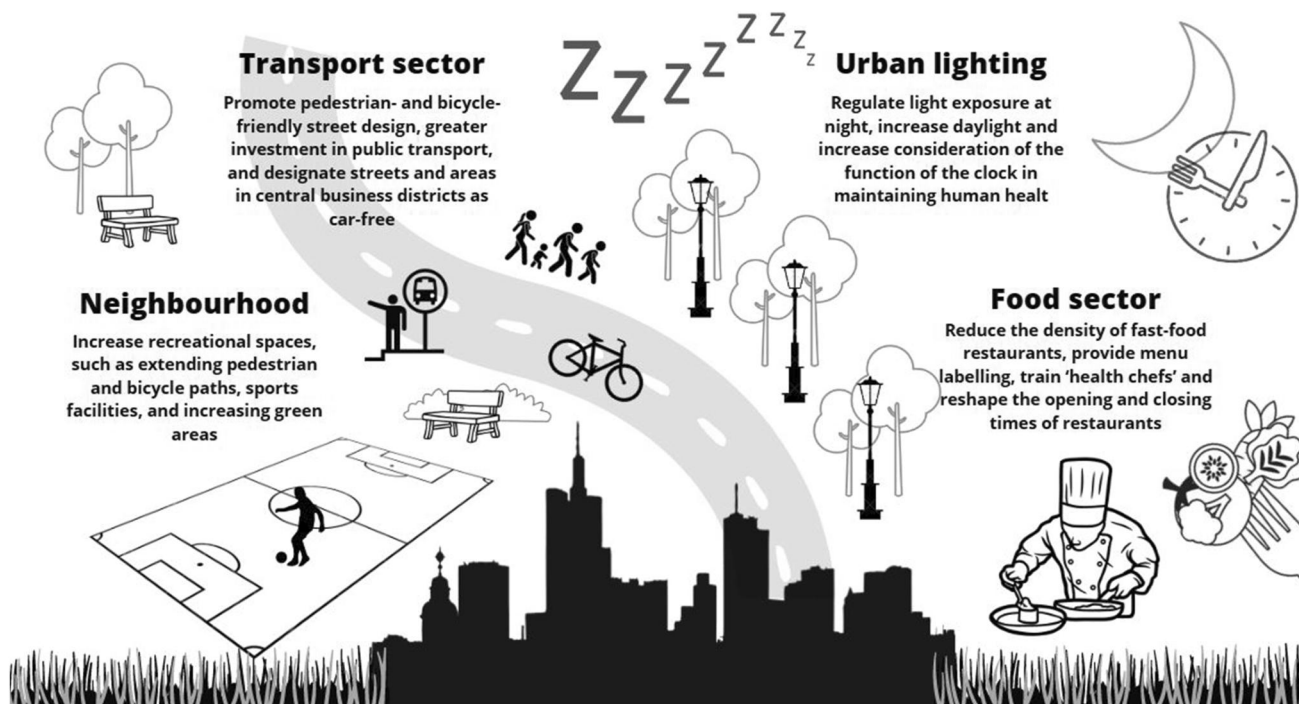


FIGURE 1 Instructions to build a weight-friendly city.

metabolic pathways.<sup>53</sup> Of relevance, host circadian rhythmicity and lipid metabolism are increasingly recognized to cross-regulate, and the circadian clock-lipid metabolism interplay may be involved in the development of obesity.<sup>54</sup> In addition, ALAN affects the rhythmicity of the human lifestyle by facilitating increased work, sleep, and eating in hours of darkness.

- **Key messages.** Scientific evidence establishes a link between ALAN exposure and the obesity pandemic. This evidence will feed into future efforts to regulate light exposure at night, increase daylight, and increase consideration of the function of the clock in maintaining human health.

## 6 | CONCLUSION

Increasingly obesogenic environments are the predominant driving forces behind the growing obesity epidemic and require increased attention for research and action. Priorities must be set according to local, regional, and national circumstances by mediating between integrating intervention efforts into existing activities and perhaps even creating intervention programs from scratch (Figure 1). The strength of an environmental approach is that even modest impacts can have population benefits if large numbers of people are exposed to that environment. Small changes and large volumes are the nature of the upward and downward trajectories of non-communicable disease epidemics. The challenge ahead is to identify obesogenic environments and influence them in such a way that options that support an otherwise anti-obesogenic environment are more readily available, more easily accessible, and widely promoted

to a large portion of the community. This will require a paradigm shift to recognise obesogenic environments as major drivers and recruit the non-health sectors as essential allies in addressing the obesity epidemic. Similarly, non-health sectors, such as local governments, neighborhoods, transport, and food sectors, also need a paradigm shift to see their contribution to reversing the obesity epidemic.

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### CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

### DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

### PEER REVIEW

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