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REVIEW



Upstream Determinants of Overweight and Obesity in Europe

Stefanie Vandevijvere 1 • Robby De Pauw 1 · Sanne Djojosoeparto 2 · Vanessa Gorasso 1 · Leonor Guariguata 1 · Anne Lene Løvhaug 3 · Melissa Mialon 4 · Iris Van Dam 1 · Peter von Philipsborn 5

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Abstract

Purpose of Review To review the upstream determinants of overweight and obesity in Europe, including food and built environments, and political, commercial, and socioeconomic determinants.

Recent Findings Overweight and obesity affect 60% of European adults, and one in three children, and are more common in individuals with low compared to high socioeconomic position (SEP). Individuals in low SEP groups are more exposed to unhealthy built and food environments, including higher exposure to unhealthy food marketing. Industries influencing the food system have much economic power, resulting in ignoring or silencing the role of ultra-processed foods and commercial practices in weight gain. Overall, effective policies to address overweight and obesity have been insufficiently implemented by governments.

Summary To accelerate implementation, strengthened political commitment is essential. Policies must also focus on the upstream, structural, and systemic drivers of overweight and obesity; be comprehensive; and target socioeconomic inequalities in diets and physical activity.

Keywords Overweight and obesity · Upstream determinants · Commercial determinants of health

Introduction

Overweight and obesity constitute a significant risk factor for developing several non-communicable diseases (NCDs), such as cardiovascular diseases [1], type 2 diabetes mellitus [2], and some types of cancer [3]. More than 13% of total deaths across the World Health Organization (WHO) European region are attributed to overweight and obesity [4••]. In addition, overweight and obesity negatively affect

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Pettenkofer School of Public Health, Ludwig-Maximilians-Universität München, Munich, Germany psychosocial outcomes and health-related quality of life [5]. Moreover, the societal costs of overweight and obesity are substantial, including the direct cost of treating obesity-related diseases and the indirect costs, through lost productivity due to illness or premature death [6]. In 2017, it was estimated that the annual financial cost of overweight and obesity in Europe was approximately €70 billion, with the majority of these costs being borne by healthcare systems and governments [7]. Consequently, there is growing momentum and consensus on the need to prevent and control overweight and obesity [8]. However, no country in the world, including countries in the WHO European Region, is on track to achieve the World Health Assembly target of halting the rise in adult obesity prevalence by 2025 [9–11].

Identification of effective measures to address the burden of overweight and obesity requires examination of its determinants, or influencing factors. Obesity is influenced by multiple determinants functioning at multiple levels, with important interactions between these levels [12]. At the individual level, determinants include factors such as genetics, biology, and psychology, as well as dietary and physical activity behaviors. Strategies for addressing overweight and obesity in the European Union to date have mainly addressed



determinants at this level, focusing on individual behavior change through awareness campaigns and education [13]. However, as such strategies have been insufficiently effective [13], there is a growing recognition about the need to understand and address the more upstream determinants of overweight and obesity. An upstream determinant of obesity is defined as any contextual characteristic (i.e., beyond individual-level characteristics) that influences obesogenic behaviors (defined as behaviors that increase the risk for obesity) [15]. Upstream determinants can take the form of tangible characteristics in the food or built environments of individuals (e.g., fast-food outlets, fresh produce markets, walkability), or manifest as-and interact with-less tangible features in economic, political, and sociocultural environments [15]. Upstream determinants are also described as drivers of overweight and obesity with systemic drivers (root causes) at the most distal end and environmental drivers at a more proximal end [16].

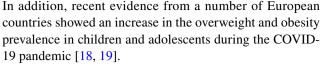
Measures that address upstream determinants of overweight and obesity are considered more effective and sustainable than those addressing determinants at the individual level as they can improve the overall conditions and underlying mechanisms that contribute to overweight and obesity [16].

Based on the scholarly discourse on the upstream determinants of overweight and obesity [15], the aim of this paper is to assess the following more proximal and distal upstream determinants of overweight and obesity in Europe: food and built environments ("what is available"), political determinants ("what are the rules"), commercial determinants ("what are the relevant industry strategies and practices"), and socioeconomic determinants ("what are the daily living conditions").

Following this overview, possible solutions to address overweight and obesity in Europe are suggested. We start by reviewing the trends of overweight and obesity in Europe and their direct determinants, to establish the scale of the challenge.

Trends in Overweight and Obesity in Europe

The prevalence of overweight (including obesity) in the WHO European Region has increased steadily between 1975 and 2016, from slightly less than 40% in 1975 to slightly less than 60% in 2016. The prevalence of obesity has risen from 10% in 1975 to 24% in 2016 [4••]. According to the WHO, almost 60% of adults (63% of males and 54% of females) and nearly one in three school-aged children (29% of boys and 27% of girls) were living with overweight or obesity in the European region in 2016 [11, 17]. In 50 out of 53 WHO Europe member states, more than half of the adult population is currently living with overweight or obesity [11].



The percentage of adults and children living with overweight or obesity is higher among individuals with a low versus high socioeconomic position (SEP) in most European countries, particularly in high-income countries [4••]. In some middle-income countries, reversed trends can be observed, with higher prevalence of overweight and obesity in high compared to low SEP groups [4, 20]. Nevertheless, evidence shows that the burden of overweight and obesity shifts to groups with lower SEP as countries develop economically [21].

Trends in Population Diets and Physical (In) activity in Europe

Dietary intake and physical (in)activity are direct behavioral determinants of overweight and obesity [22] and are outcomes that can be changed by addressing the upstream determinants.

In Europe and globally, changes in dietary patterns have contributed to an increasing overconsumption of calories. Importantly, the consumption of ultra-processed foods, often energy-dense and high in saturated fats, sugar, salt, and additives, has increased substantially, a trend linked to weight gain and obesity [23, 24], even after adjusting for overall dietary patterns [25, 26]. Sales of ultra-processed foods are high in Europe compared to other world regions [27, 28], and contribute to 25% of total calorie intake on average (ranging from 14 to 44% across European countries), mostly in the form of bakery wares made from refined grains as well as soft drinks [29].

A significant association has been found between the household availability of ultra-processed foods and the prevalence of obesity among European adults [26]. In addition, European young children frequently consume diets high in ultra-processed food products [30]. Crises in recent years in Europe have also influenced food consumption; the COVID-19 pandemic for example contributed to an increased consumption of unhealthy foods in some countries [31–33].

Socioeconomic inequalities are also reflected in population diets [34]. For example, dietary intake tends to be healthier in higher SEP groups and less healthy among lower SEP groups [35–38]. In Europe, ultra-processed food consumption, including sugary drinks consumption, in children tends to be highest among people with multi-dimensional socioeconomic disadvantages [38, 39]. Additionally, low fruit and vegetable intake has been observed in children whose parents have low educational attainment across highand middle-income countries in Europe [38].



Besides, Europe also currently has the lowest breastfeeding rates in the world, with only one in four children being exclusively breastfed for the first 6 months [40, 41]. It has been shown that breastfed infants less frequently develop overweight or obesity when growing up [42–44].

In addition to unhealthy diets, increased levels of physical inactivity also contribute to the obesity epidemic and related health issues [45]. Less than one-third of European children and adolescents reach recommended levels of physical activity [46]. The trend in levels of physical activity between the mid-1980s to the early 2000s among European adolescents has remained more or less stable [47]. In high-income countries, levels of physical activity tend to be lower among low versus high SEP groups, especially for leisure time or sports-related physical activity [48–51]. Pooled data from 24 European countries show disparities in screen time, sport club participation, and active travel to school among 6–9-year-old children [52]. By contrast, sedentary behavior, another determinant of overweight and obesity, appears to be more equally distributed among socioeconomic groups [48, 49].

Upstream Determinants of Overweight and Obesity in Europe

The Role of Food and Built Environments as Determinants of Overweight and Obesity

Environmental determinants of overweight and obesity are important influencers of population diets and physical (in) activity. The term "obesogenic environment" was coined more than two decades ago to describe how modern environments drive the obesity epidemic [53]. *Food environments* comprise "the collective physical, economic, policy and sociocultural surroundings, opportunities and conditions that influence people's food and beverage choices and nutritional status" [54].

Obesogenic food environments are characterized by an increased availability, affordability, and promotion of energy-dense, nutrient-poor foods compared to fresh, healthy foods [55–57]. These environments include the multiple challenges related to digital food environments, including digital marketing of unhealthy food products to children, online gaming, and meal delivery apps offering mostly unhealthy foods [58].

Built environments include environments that focus on the human-made spaces in which people live, work, and recreate on a day-to-day basis [59, 60]. Built environments consider aspects such as transportation systems, urban planning, and walkability of neighborhoods [61, 62]. Aspects in built environments that can be associated with physical (in) activity are walkability, the access to recreational facilities, the proximity of shops, and the availability of parks and playgrounds [45].

Both food and built environments significantly affect dietary intake and physical activity, and with that overweight and obesity, mostly through the availability and accessibility of (un)healthy products and the extent to which the environments support active travel (such as walking and cycling) and recreational physical activity [14, 16, 54, 61]. Food and built environments in Europe currently often make the unhealthy choices the easier choices, through a high availability of unhealthy, energy-dense, ultra-processed foods and through built environments which discourage active travel and active recreational activities [8, 14, 16, 26, 63]. Besides, access to health-promoting food and built environments is socially patterned. People in low SEP groups are, on average, more strongly exposed to unhealthy food and built environments [64-66], including limited access to safe and pleasant green areas [67, 68] and higher exposure to marketing of unhealthy foods [69], limiting their opportunities for health-promoting behavior [4...]. Moreover, people in low SEP groups may have an increased vulnerability to unhealthy environments, as a result of unfavorable factors, such as financial problems and stress [4••].

Political Determinants of Overweight and Obesity

Politics can loosely be defined as the structures (e.g., states), processes (e.g., elections, law-making), and outputs (e.g., policies, laws, taxes) that will ultimately produce the health and other societal outcomes of interest [70]. The political determinants of overweight and obesity create the structural conditions and the societal drivers—including access to healthy food options and poor daily living conditions—that affect key dynamics involved in developing overweight and obesity [71].

While there are a number of internationally recommended evidence-based policies that governments can implement to prevent and control overweight and obesity [72], their development and implementation is slow and inadequate and can be challenging due to several political factors. The implementation of nutrition and physical activity policies is highly uneven and influenced, among others, by political commitment, (in)adequate prioritization, cross-sectoral coherence and capacity, financial resources, advocacy activities, and lobbying by commercial actors [73, 74].

Currently, governments in Europe are still mainly implementing non-structural and individual-level policies that aim to inform people (e.g., awareness campaigns, education, health advice), instead of structural policies to create healthy food and built environments [13]. The Lancet Commission report "The global syndemic of obesity, undernutrition, and climate change" pinpointed specifically how policy inertia, defined as insufficient political leadership and governance,

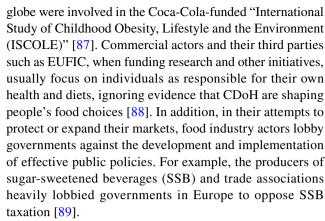


often stemming from opposing commercial interests and insufficient public demand, forms a key barrier to progress on the implementation of recommended policies for the prevention and control of overweight and obesity [14].

Commercial Determinants of Overweight and Obesity

The commercial determinants of health (CDoH) are defined as "the systems, practices, and pathways through which commercial actors drive health and equity" [75]. In the context of overweight and obesity, several industries are of relevance. This includes the food industry, made up of different actors such as food manufacturers, suppliers of raw materials and ingredients, retailers, public relations agencies, and trade associations, among many others. Some segments of the food industry produce foods that contribute positively to people's health. However, the majority of food and beverage products, including baby food products, on the markets in Europe do not meet minimum standards for healthy foods [76, 77]. Marketing is another commercial practice that shapes people's preferences and choices [78]. Combining marketing types (advertising, promotion or cross-promotion, and sponsorship), techniques (licensed or brand-equity characters, celebrity endorsers, and incentives (e.g., toys)), and channels (print, broadcast, outdoor, social media) can powerfully reinforce commercial messages. For example, influencers promote branded products by featuring them in online videos; and branded products are shown prominently during sponsored events [79]. The marketing of ultra-processed products contributes to an increased consumption of such products and to the displacement of healthier foods [80]. Similarly, aggressive marketing of infant formula has been shown to reduce breastfeeding rates [81]. In few cases, instore marketing has been used to increase fruit and vegetable purchases [82].

There are several corporate political activities used by industry to influence research, policy, and practice [83]. For example, there are front groups funded by food companies that may appear objective and may partner with credible academic institutions in Europe. The European Food Information Council (EUFIC), whose membership includes Coca-Cola, Nestlé, and PepsiCo [84], is an example of that. Moreover, food industry actors fund research that promotes their interest. Coca-Cola for example set up the Global Energy Balance Network (GEBN), with credible academics, to focus on the lack of physical activity as the primary driver of obesity—and remaining silent on the role of its products in ill-health [85]. This partnership faced criticism after it was exposed in the media, and the network stopped all activities [86]. In Europe as well, food industry actors fund research on obesity that promote their commercial interests. Dozens of academics from across the



Taken together, the food industry has much economic power which translates in a promotion of market-based solutions to obesity.

Commercial actors involved in the built environment, including in transportation and urban planning, also have a key influence on people's health, but this has been a lot less documented, and needs to be further researched [90].

Socioeconomic Determinants of Overweight and Obesity in Europe

The socioeconomic or social determinants of health are the conditions in which people are born, grow, live, work, and age, i.e., the daily living conditions [91]. These daily living conditions are shaped by the distribution of money, power, and resources, which are themselves influenced by policy decisions [71]. Examples of these conditions which can affect health equity in either positive or negative ways are income, education, (un)employment and job (in)security, food (in)security, and housing conditions [92]. It has been argued that nutrition and obesity prevention research and policy also need to include intellectual disability as part of equity considerations. People with intellectual disability have disproportionately higher rates of obesity [93].

Socioeconomic status is a strong determinant of overweight and obesity, both within and across countries [94]. In Europe, about 1 in 5 children, on average, live in relative poverty [95]. The varied prevalence of childhood overweight and obesity rates, particularly between those of Southern European countries and Northern/Western European countries, may also partly be attributable to differences in socioeconomic factors [96].

As a result of unfavorable daily living conditions (e.g., financial problems, poor housing, stress), people in low SEP groups may have no time, money, or energy left for making deliberate healthy choices, leading to an increased vulnerability to unhealthy environments [4••].

Thus, obesity prevention requires not only action on food and built environments, but also consideration of people's broader daily living conditions and context and how



these are influenced by other upstream determinants [4••]. Although the exact mechanisms by which socioeconomic status exerts its effects are not always apparent [94], the mechanisms related to poverty and having a low income seem rather straightforward [97]. Socioeconomic inequalities are associated with inequities in employment and income opportunities [98], influencing how much budget a person or family can afford to spend on foods and beverages or sports. The higher costs of healthy foods compared to unhealthy foods, the higher convenience of unhealthy compared to healthy foods, and the high costs of organized sports are perceived to be contributing to unhealthy behaviors, particularly among people on low incomes [33, 99–102].

However, to account for all the determinants involved in the numerous underlying mechanisms between socioeconomic position and dietary intake and physical (in)activity, a system perspective should be applied [97, 103].

Links of Overweight and Obesity with Other Public Health Challenges

The challenge of addressing the upstream determinants of overweight and obesity in Europe and globally is closely linked with a number of other key societal challenges in the area of public health and beyond [104••]. Healthy diets and physical activity are not only crucial for preventing obesity, but also for a considerable number of other important health outcomes [5].

For example, current dietary patterns that are high in animal-derived foods and that encourage calorie overconsumption contribute substantially to climate change (between one-quarter and one-third of all anthropogenic greenhouse gas emissions originate from the food system), as well as to other processes of environmental change, such as biodiversity and habitat loss and air and water pollution, which are all threatening global food security [105]. Many of these detrimental environmental impacts could be reduced by moving towards dietary patterns that are both healthy and environmentally sustainable, i.e., diets that are characterized by an optimal caloric intake and consist largely of a diversity of plant-based foods, low to moderate amounts of animal-sourced foods, and limited amounts of refined grains, ultra-processed foods, and added sugars [105].

Similarly, a shift away from our current, car-focused model of mobility towards more active transport (cycling and walking in particular) would not only increase physical activity levels, but also help to reduce carbon emissions, particulate matter, and other forms of ambient air pollution, as well as traffic noise [104••]. Reducing the dependence on cars as means of inner-city transportation would allow for the creation of more green spaces in cities, which is an important determinant of mental and physical health [106].

Given these interdependencies [104••], government ministries outside of health also have an important role to play in obesity prevention policies [72].

Solutions to Address Overweight and Obesity in Europe

Public Policies

In Europe, national governments have mandates that enable them to address several upstream determinants of overweight and obesity with appropriate policies. Public policies can be defined as "purposeful decisions, plans and actions made by governments to directly or indirectly achieve specific societal goals, usually expressed in a law, a regulation, a guideline or a recommendation that reflects the government's intent or its representative entities" [107, 108].

Universal upstream public policies target the entire population and are structural; by changing the environments and other conditions that facilitate obesity, they generally require little individual effort to actually change dietary behavior or physical activity.

This makes these universal upstream government policies generally more effective in improving population health than downstream measures which address individual behaviors, such as mass media campaigns focused on health [16, 109]. Public policy can also work through controlling the commercial determinants of overweight and obesity [110].

Universal, upstream policies to improve food environments include, among others, reducing the prices of healthy foods while increasing those of unhealthy foods (e.g., through taxes and subsidies), providing healthy food in schools and other public organizations, and restricting marketing of unhealthy foods [111]. Universal, upstream policies that create environments stimulating physical activity include, for instance, sustainable urban mobility plans, such as policies that provide convenient, safe, and connected walking and cycling infrastructures; promote active travel; and support to public transport [107].

Upstream government policies that lead to healthier environments are also considered promising to reduce socioeconomic inequalities in health [112]. These policies can lead to an improvement of the unfavorable environmental features to which people in lower socioeconomic groups are more often exposed or are more vulnerable as a result of less favorable daily living conditions (e.g., unfavorable housing conditions, financial constraints) [113]. In addition, policies that create fairer income, employment, and education opportunities may contribute to reducing overweight and obesity [114, 115]. While there is some evidence to suggest that social protection policies can improve employment, education, socioemotional, and well-being levels [116, 117], national spending



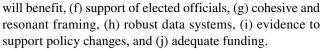
on social protection has decreased on average across the WHO European Region in recent years [95].

However, the implementation of universal, upstream policies is low in Europe [107, 118]. A large disparity exists among the type and breadth of policies adopted by governments in Europe, with a mix of single-issue policy responses and more cohesive strategies. Thirty-two countries (out of 53) within the WHO European Region have a publicly available national health or obesity strategy [119].

Some governments in Europe implemented interventions that target recommendations across the spectrum of the WHO Ending Childhood obesity implementation plan [119]. For example, the Finnish government provides subsidies for healthy school meals for all pupils and students [120]; Portugal implemented a law to restrict advertising of unhealthy foods to children under 16 years old covering schools, public playgrounds and surroundings, television, on-demand media services, radio and cinema, and websites and social networks (though not influencer marketing) [118], and Catalonia (Spain) has implemented national or regional programs that support sustainable urban mobility plans [121]. Furthermore, the EU has implemented policies such as the EU school scheme, which provides funds and organizational support to member states for providing school children with fresh fruit, vegetables, and dairy products. Member states set the specific rules, but according to the European Commission, most countries do not allow added sugar, salt, fat, and sweeteners or artificial flavors in products distributed through the program [122]. The current budget is €220 million per school year, and the program reached approx. 15 million children in the year 2020/2021 [123]. However, there is large potential for the EU to strengthen its policies in order to improve food environments and prevent overweight and obesity [124]. Thus, while there are some examples of successful policies, implementation of the full set of internationally recommended policies (in particular, marketing restrictions, fiscal policies, and nutrition standards in schools) is seldom seen, either at national or European levels [118, 119].

Strengthening Political Commitment

To successfully develop and implement recommended policies, high-level long-term political commitment, strong political leadership, and supportive government administrations are needed [125]. The following factors were found to be crucial to increase and strengthen the number of policy efforts addressing overweight and obesity [126, 127]: (a) strong multisector coalitions, (b) effective grassroots initiatives, (c) civil society mobilization, (d) effective communication strategies to contribute early on to a framing of the policy debate that is aligned with the relevant evidence, (e) a clear articulation of the purpose of the policy and who



Emerging approaches to strengthen political commitment for overweight and obesity prevention focus on a rights-based framing of public health issues, aligning with the United Nations Convention on the Rights of the Child, which recognizes that children have the right to nutritious foods and healthy environments [128, 129]. For example, the Greater London Authority has implemented a rights-based, citizen-centered approach to an equitable nutrition policy, with the ambition that every child in London should be able to maintain or achieve a healthy weight. Ten shared priority policy actions were derived from different children's voices and lived experiences, including making free "London Water" available everywhere, creating more active, playful streets and public spaces and transforming fast-food businesses [130].

Systemic Solutions

The lack of progress on overweight and obesity prevention described above may be linked to the framing of obesity as a consequence of "lifestyle choices." Indeed, in 2007, the European Commission prefaced their "Strategy for Europe on Nutrition, Overweight and Obesity related health issues" by saying that any action undertaken should remember that "the individual is ultimately responsible for his lifestyle and that of his children..." and that "only a well-informed consumer is able to make rational decisions" [131].

Researchers increasingly recognize this type of language as benefiting the commercial interests that shape the obesogenic environments, and have questioned the appropriateness of this concept in the context of obesity prevention [132]. To move away from the simple cause-and-effect, personal responsibility mindset of obesity and its determinants, we must examine the complex drivers that have led to the rise in overweight and obesity in order to develop effective ways to intervene [133].

In 2013, the US Institute of Medicine called for a systems approach to preventing obesity [134] in recognition of the complex nature of its determinants.

The determinants of the obesogenic environment are described as "function[ing] at multiple levels, with important interactions between these levels" [12]. Systems thinking approaches challenge users to look beyond simple cause-and-effect relationships to develop wider networks of competing and complex feedback mechanisms. These can be challenging to develop and communicate, but using these techniques with stakeholders has shown to develop systems thinking and help drive consensus [135].

Systems thinking methods hold the promise of developing and coordinating policies in a truly multi-sectoral



way, although the efficacy of systems thinking methods in achieving improvements in obesity prevention is still lacking because of the challenge of successfully implementing and evaluating multiple initiatives simultaneously across a vast complex system [136]. Nevertheless, researchers are increasingly using a systems lens to examine the connections and potential co-benefits for multiple outcomes when envisioning policy interventions. An example of this is the Lancet Commission report on "The global syndemic of obesity, undernutrition, and climate change" [14]; the report uses a systems approach to identifying win–win-win intervention points that integrate policy.

Applying systems approaches in obesity prevention is relatively new and may take many years before the benefits could be measured [137] although successful examples exist in the field of infectious diseases [138] and health systems planning [139]. Recently, the WHO Regional Office for Europe published a manual for integrating systems thinking for NCD policy development which provides useful guidance [140]. An example applying a systems approach within the Amsterdam Healthy Weight Programme among adolescents in lower socioeconomic neighborhoods showed similarities in the dynamics for four behaviors influencing obesity risk (diet, physical activity, sedentary behavior, and sleep) in that they are influenced by proximate subsystems (such as home and school environments), as well as by more upstream subsystems, including macroeconomics, social welfare, and urban systems. The created causal loop diagrams provided insights that can support the development of intervention strategies, including the confirmation that a range of mechanisms cover and connect multiple levels and settings, meaning that there is no silver bullet to address obesity. Moreover, they showed how interventions in one particular setting, such as at school, might be influenced by the interactions with other settings, such as urban systems, and provided a comprehensive view of (un)intended consequences [141].

An evaluation of childhood obesity strategies by the WHO Regional Office for Europe found that comprehensive all-of-society approaches at multiple levels are being implemented in Ireland and France, although it is still early to see an impact in childhood obesity prevalence [119]. Similarly, an evaluation of policies acting outside the health sector in Spain and their impacts on childhood obesity found that a health-in-all-policies approach can be built into a policy strategy when there is good commitment [142]. Furthermore, strategies for adults or the whole population are much less developed. A review of European countries and the USA found that whole-of-population approaches to obesity prevention are rarely considered and that policies are still strongly influenced by industry interests [143]. The challenge remains one of understanding and acting on the determinants of the broader obesogenic system.

Conclusion

Overweight and obesity affect almost 60% of adults in the WHO European Region, with nearly one in three children living with overweight or obesity. Obesity is complex, with multifaceted determinants and health consequences. Multiple interventions are needed to halt the rise of overweight and obesity in Europe, but implementation of effective policy actions across Europe is currently insufficient. To accelerate implementation, strengthened political commitment is essential, and policies must also focus on the upstream, structural, and systemic drivers of overweight and obesity; be comprehensive; and target socioeconomic inequalities in diets and physical activity to ensure equal access to healthy food and built environments.

Compliance with Ethical Standards

Conflict of Interest The authors declare not having any conflicts of interest in regard to this study.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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