BMC Medicine

RESEARCH

Open Access

Understanding the underlying systems dynamics contributing to the continued predominance of the unhealthy motorway food environment in the Netherlands: identifying leverage points and actions for change

Lisanne Geboers[1], Coosje Dijkstra[2,3], Frédérique C. Rongen[1], Sanne K. Djojosoeparto[1] and Maartje P. Poelman[1*]

Abstract

Background Motorway food environments are dominated by roadside restaurants and petrol station stores offering predominantly unhealthy quick-service meals and foods for on-the-go consumption. Improving these environments to promote healthier diets is necessary, but how to achieve this is not fully understood. Therefore, this study aims to identify the complex underlying systems dynamics contributing to the continued predominance of the unhealthy motorway food environment as well as to identify potential leverage points and corresponding actions for change to improve the healthiness of the motorway food environment.

Methods Two Group Model Building workshops were held in October 2023 with motorway food environment stakeholders (e.g. food providers, producers, national policymakers, truck drivers). In the first workshop, a Causal Loop Diagram (CLD) was created to identify the system that contributes to the continued predominance of the unhealthy motorway food environment. The research team then identified leverage points for change based on the CLD. During the second workshop, stakeholders formulated actions to improve the motorway food environment for each identified leverage point. Leverage points and actions were classified based on the Action Scales Model (ASM).

Results The resulting CLD comprised six interconnected subsystems (food providers, supply chain collaboration, government, social culture, road users, global trends) with six reinforcing feedback loops, underlying the continued predominance of the unhealthy motorway food environment. Additionally, 14 potential leverage points and 31 corresponding actions for change were identified at different levels of the system based on the ASM (i.e. events, structures, goals and beliefs).

Conclusions The findings show many interrelated factors and mechanisms underlying the continued predominance of the unhealthy motorway food environment. Actions for change were proposed together with stakeholders aimed at leverage points at different system levels. The results show that the motorway food environment is shaped by broader societal goals and beliefs (e.g. the profitability of unhealthy products) and social-cultural beliefs particularly evident to the on-the-go setting, including the motorway food environment. Together they present the strongest

*Correspondence:
Maartje P. Poelman
maartje.poelman@wur.nl
Full list of author information is available at the end of the article

potential for leveraging systems change. There is a need for a coherent multidimensional action plan targeting these leverage points, which is broadly supported by various stakeholders, to induce systemic change.

Keywords Food environment, Motorway, Group Model Building, Causal Loop Diagram, Participatory approach, Systems thinking

Background

Overweight and non-communicable diseases (NCDs) such as obesity, cardiovascular diseases, type 2 diabetes and several forms of cancer form significant public health challenges [1, 2]. A primary contributor to overweight and NCDs are unhealthy diets [3]. There is increasing evidence that exposure to unhealthy food environments plays a significant role in promoting poor dietary choices and thereby unhealthy diets [4]. Conceptually, food environments are defined as the collective physical (e.g. availability), economic (e.g. prices), policy (e.g. rules) and sociocultural (e.g. norms) surroundings, opportunities and conditions that influence people's food and beverage choices and nutritional status [4]. A specific context where unhealthy food options dominate is the food environment at motorway stops [5–8]. These motorway food environments are dominated by roadside restaurants and petrol station stores offering quick-service meals and supplying portable foods for on-the-go consumption. Prior research into this food environment in the USA showed that these restaurants offer predominantly unhealthy food, with the food offered only being 18.1% in support of healthful eating [6].

Every day, many people are exposed to this food environment at motorway food providers and purchase food at these locations [9]. To illustrate, on average, 1.3 million people in the Netherlands visit the petrol station shop daily [9]. An online questionnaire study among visitors of motorway petrol stations showed that 47% of the respondents buy food or beverage products there [9]. This study also indicated that the most often bought food and beverage products are snacks, confectionery (i.e. crisps, candy) and cold beverages (i.e. soft drinks, juices and energy drinks), with these purchases suggested to be predominantly impulsive [9]. A more recent study among Dutch truck drivers showed that 36.8% of them purchased food or beverage products at least once a week at a petrol shop station during work hours.[1]

Whilst the Dutch government has previously recognised the need to improve motorway food environments to promote healthier diets, as emphasised by its commitment to offering healthier food options at motorway food providers in the National Prevention Agreement (NPA) [10], *how* to effectively improve this setting is still not fully understood [11]. First of all, the motorway food environment is an understudied area [5, 6], but more importantly, we lack an understanding of the underlying factors and dynamics that shape the continued predominance of the unhealthy motorway food environment [6]. This food environment can be suggested to operate as a complex system, influenced by multiple stakeholder groups (e.g. the government, food providers) driven by many interconnected influencing factors ranging from individual road user factors to broader supply chain factors [12]. Therefore, to determine what interventions or strategies can effectively improve the motorway food environment in a lasting way, it is important first to investigate the complex system causing this continued predominance of the unhealthy food environment. This is to prevent well-intended interventions or strategies targeting the wrong mechanisms of the systems, leading to ineffective or even negative consequences [13].

A way to understand these complex systems is via system dynamics, which creates a shared understanding of a complex system by seeing how systems adjust to changes (adaptation), respond in cycles of cause and effect in closed causal loops (feedback loops) and produce outcomes that are greater and often unpredictable compared to the individual parts involved (emergence) [14]. Within system dynamics, Group Model Building (GMB) is an established practice that engages stakeholders in a modelling process, allowing them to collectively gain an understanding of the dynamics of a complex system [15]. Using this GMB approach, Causal Loop Diagrams (CLDs) can be created by stakeholders which offer a visual overview of the current system of the motorway food environment. The CLDs present the identified factors, the interconnections between these factors and the feedback loops [15, 16]. Furthermore, CLDs can also serve as a starting point to identify leverage points for change, the development of impactful actions and enhancing stakeholder and community participation [16]. Whilst CLDs have already been utilised in food environment research [13, 17, 18], no studies, to our knowledge, have focused on the specific motorway food environment and the unique factors and dynamics shaping it. Therefore, this study used a GMB approach with stakeholders, aiming to identify the underlying systems dynamics contributing to the continued predominance of the unhealthy motorway

[1] Geboers et al., in preparation.

food environment as well as to identify potential leverage points and corresponding actions for change to improve the healthiness of the motorway food environment.

Methods

Study context

This study was part of and funded by the Regio Deal Foodvalley (grant nr. 162135). Regio Deal Foodvalley is a collaboration between the Dutch national government and the Foodvalley Region in the Netherlands, which includes eight municipalities in this region in the Netherlands. Renowned for its knowledge and innovation in healthy and sustainable food, the Foodvalley Region is a top region in its field, aiming to accelerate the transition to a sustainable and healthy food system [19]. This study was conducted together with the Netherlands Nutrition Centre, which is an independent organisation for encouraging consumers to make safe, healthy and sustainable food choices, funded by the Ministry of Agriculture, Nature and Food Quality and the Ministry of Health, Welfare and Sport.

Study design

A GMB approach was used, consisting of two GMB workshops that were conducted in October 2023 [15]. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Social Sciences Ethics Committee (SEC) from Wageningen University. Written informed consent was obtained from all participants.

Participants and recruitment

We aimed to include a diverse range of stakeholders connected to the motorway food environment in the workshops. We first explored the different stakeholder groups through stakeholder analysis utilising the power-interest matrix subject [20]. This power-interest matrix classifies stakeholders into four categories according to the degree of power and interest they have in the subject, allowing exploration of the complexity of stakeholders and their differences in power and interests. Stakeholders identified in the power-interest matrix, along with additional stakeholder groups found through media publications and network exploration, were included in the proposed stakeholder pool. The proposed stakeholder groups included food providers at motorway stops (i.e. roadside restaurants, petrol station shops, fast-food chains), food producers, retail organisations in the petrol industry, suppliers, concept developers, public health organisations, partners of the Foodvalley region, national policymakers, truck drivers, trade organisations groups (for petrol stations, the catering sector, food producers, the transport and logistics sector, employability in transport and logistics and passenger and truck dealers), experts in infrastructure and planning, financial institutions, news platforms of the petrol (food) industry and an expert in fast-charging electric vehicles. Most stakeholders also had firsthand experience as road users themselves, providing valuable insights from both professional and personal perspectives. Employees from these various companies and institutions were invited through cold-calling, cold-mailing and cold-LinkedIn messaging. Additionally, invitations were extended through the research team network, the Netherlands Nutrition Centre and online promotions in sector-specific newsletters and on LinkedIn. A total of 132 invitations were sent to 99 companies and institutions. The invitation requested the presence of an employee, preferably in a management role, who was professionally involved with the motorway food environment, at our workshops. If the initially invited employee could not attend, they were asked to recommend colleagues in the relevant field who could participate. The invitation provided information on the study's aim and procedure, a link for workshop application and informed participants of financial compensation of fifty euros per hour and coverage of travel expenses for their participation.

Study procedure and data collection

This study used an iterative GMB approach involving two workshops. Participants collectively built a CLD and identified actions to improve motorway food environments. This was followed by further analysis from the research team to refine the CLD, identify leverage points and conduct further analysis of the CLD. Both workshops took place in a central location in the Netherlands and lasted 3 h.

GMB workshop 1

The first GMB workshop aimed to create a CLD, to identify and illustrate the system that contributes to the continued predominance of the unhealthy motorway food environment. This involved identifying the most important factors and their interconnections that shape this system. The workshop started with an introductory opening and explanation of the food environment followed by multiple GMB techniques that were based on scripts [21]. First, the participants individually wrote down their hopes and fears to elicit and establish their expectations for the workshop. These expectations were then briefly discussed in a plenary session. Next, participants were divided into seven groups, each consisting of five to six participants. The groups consisted of participants from different stakeholder groups and were led by a member of the research team who also took notes. First,

participants individually identified factors influencing the continued predominance of the unhealthy motorway food environment according to the Graphs Over Time script [21], with all identified factors being documented. Second, participants were instructed to discuss and choose the five most important factors in their group. After this, each group named their most important factors in the plenary session, until a final list of about 20 to 30 factors was reached. In this plenary session, the factors were discussed in terms of their influence on the unhealthy motorway food environment. The discussion concluded by questioning whether these factors were indeed the most important which was confirmed by the group. Third, participants made a connection circle in a plenary session, in which the connections between these factors were identified, resulting in the creation of the concept CLD. Participants were asked to indicate whether connections were either accompanied by a plus (+) or a minus (−) sign. A plus sign indicated that when the initial factor increased, the receiving factor also increased, and similarly when the initial factor decreased the receiving factor also decreased (positive relationship). Contrarily, a minus sign indicates that when the initial factor increased, the receiving factor decreased, or when the initial factor decreased the receiving factor increased (negative relationship) [15]. These factors formed a feedback loop when one factor influenced other factors, either reinforcing (+) or balancing (−), thereby creating a continuous cycle with the initial factor [14]. Whilst these loops represent key dynamics, additional system dynamics may exist. This concept CLD offered a visual overview of the identified factors influencing a complex problem, illustrating the interconnections between these factors and feedback loops according to stakeholders [15, 16]. The full programme of GMB techniques used in workshop 1 can be found in more detail in Supplementary Table 1, Additional file 1. Systems Thinking In Community Knowledge Exchange (STICKE) software was used to form the identified factors and connections into a CLD [22].

The research team present during workshop 1 consisted of eight researchers, in which each team member fulfilled a specific role. Two researchers played the role of facilitator and timekeeper (MP and CD), of which one was also the physical wall builder (MP). Another researcher was the digital wall builder (TW) and the team members were note-takers during the session (LG, JW, SD, FR, TW, MP, WH).

Refinement of CLD and identifying leverage points

After the first workshop, the concept CLD was refined based on the notes of the first workshop by the research team (CD, MP, FR, SD, LG). First, additional factors were added based on factors named by participants in the Graphs Over Time notes. Second, duplicate factors or similar concepts were eliminated and merged. Factors were adjusted to ensure neutral labelling, quantifiability of the factor and changeability of the factor [23]. Furthermore, to simplify the CLD and to prevent the CLD from becoming overloaded with connections, certain direct connections were removed when alternative indirect pathways between these elements existed. Based on the initial CLD and notes, subsystems were identified. After refining the concept CLD, the research team (CD, MP, FR, SD, LG) identified the leverage points [24]. These leverage points were determined through an analysis of the CLD, including factors embedded in feedback loops, factors that were highly connected (e.g. incoming and outgoing connections), or factors that were frequently identified by participants during the first workshop [23]. Subsequently, we aimed to determine the potential impact for systems change of the leverage points. For that purpose, we used the Action Scales Model (ASM) [25]. The leverage points were classified across the four levels of the system, namely events (behaviour and outcomes observed), structures (patterns, relationships, information flows and physical structures), goals (ambitions or targets) and beliefs (attitudes, norms, values). Each of these levels influences how the system functions; however, actions targeted at the deeper levels (goals and beliefs) have a greater likelihood of leveraging system change but they are the most difficult to change [25]. These classifications were for research understanding purposes only and were not explicitly shared with the participants during the GMB workshops.

GMB workshop 2

The second GMB workshop aimed to verify the refined CLD and to identify the most important actions to improve the motorway food environment for each of the identified leverage points. The second GMB workshop consisted of the same eight researchers with the same roles as in the first workshop, however without the role of the wall builders. The workshop started with a brief introduction to the food environment to refresh participants' memory and explain the subject to newcomers, followed by the workshop's purpose of the workshop. This was followed by the combination of multiple GMB scripts [21] and additional custom scripts tailored to this specific context (Supplementary Table 1, Additional file 1). During the introduction, the refined CLD and the leverage points were presented to the participants, on which participants were asked for their feedback. Afterward, participants were divided into seven groups of five to six participants from various stakeholder groups to identify actions for two leverage points per group.

Groups were assigned these two leverage points, to ensure coverage of all leverage points within the time available. The groups were facilitated by a member of the research team who also took notes. In these groups, participants first individually wrote down actions related to each of these two leverage points, during which they were encouraged to identify actions on different levels of the system, through the explanation and use of the ASM. By doing so we aimed to maximise the likelihood of systems change occurring and ensuring that the actions could be mutually reinforcing [25]. Subsequently, the participants discussed their actions within their group and all actions were documented. The group selected two actions that they believed would most effectively address the identified leverage point. During a final plenary session, all participants were presented with all the identified actions and a summary of the workshop, aimed at providing them with a broader perspective and deeper understanding of the dynamics of this complex system. The workshop concluded by announcing that the results would be documented in both a Dutch report and a scientific English article which would be shared with the participants. The full programme of GMB techniques used in workshop 2 can be found in more detail in Supplementary Table 1, Additional file 1.

CLD and actions refinement

The input of the participants from workshop 2 was incorporated to further refine the CLD in its present form. Furthermore, refinement strategies such as simplification were used similarly to the refinement after workshop 1. Regarding the proposed actions by stakeholders, these were classified according to the ASM. Lastly, the CLD was transferred from STICKE to the software programme Vensim 10.2.0, to visualise feedback loops and was later illustrated for this publication. In this last step, the plus and minus signs on the connections were replaced with solid and dashed lines.

Results

Participants

Ultimately, 36 participants attended the first workshop and 38 participants attended the second, including participants across 11 different stakeholder groups (see Supplementary Table 2, Additional file 2). A total of 21 participants attended both workshops, whilst 15 participants only attended the first workshop and 17 participants only attended the second workshop. Eight stakeholders from various stakeholder groups registered but did not attend the workshops, and five who participated in the first workshop registered for the second but did not show up. Participants from certain trade organisations (i.e. passenger and truck dealers, transport and logistics), experts in infrastructure and planning, financial institutions and news platforms of the petrol (food) industry did not register and were not present. Job position, stakeholder group and workshop attendance details of participants are provided in Supplementary Table 2, Additional file 2.

Causal loop diagram

In total, 52 interrelated factors, divided over six subsystems were identified (Fig. 1), including food providers [yellow]; (2) supply chain collaboration [light blue]; (3) government [dark blue]; (4) road users [green]; (5) social culture [pink]; and (6) global trends [orange]. Within the CLD, six reinforcing feedback loops were identified.

Reinforcing feedback loops are labelled in the CLD with the prefix 'R'. Solid lines indicate a positive relationship, and dashed lines indicate a negative relationship between factors. The leverage points identified are visually depicted in the CLD with numbers and underlining.

Subsystem 'food providers'

Factors related to the food providers are displayed in the left upper corner of the CLD in yellow (Fig. 1). Within this subsystem, one reinforcing feedback loop was identified (R1) towards a profit-driven cycle of contracts with suppliers and providers of unhealthy foods. This feedback loop shows that more contracts with suppliers of unhealthy products result in lower purchase prices for these items. As a result, food providers achieve higher margins on unhealthy products compared to healthy ones, increasing the profitability of unhealthy products. This heightened profitability then encourages more contracts with suppliers of unhealthy products. Additionally, a cross-subsystem feedback loop was identified between this subsystem and the subsystem of the government (R2) concerning the power of unhealthy producers on legislation and policies about a healthy food offer. This feedback loop shows that more power of unhealthy producers leads to a more powerful food lobby of this industry. The food lobby by the industry leads to the lack of governmental legislation and policies on a healthy food offer for motorway food providers. In turn, this lack of legislation and policies gives the unhealthy producers more power.

Subsystem 'supply chain collaboration'

Factors related to supply chain collaboration are displayed on the left side of the CLD in light blue (Fig. 1). Within this subsystem, one reinforcing feedback loop (R3) was identified. This feedback loop indicates that due to a lack of collective responsibility in the supply chain for a healthier motorway food environment, stakeholders are not developing an ambitious vision for a healthier food environment. This lack of ambition hinders

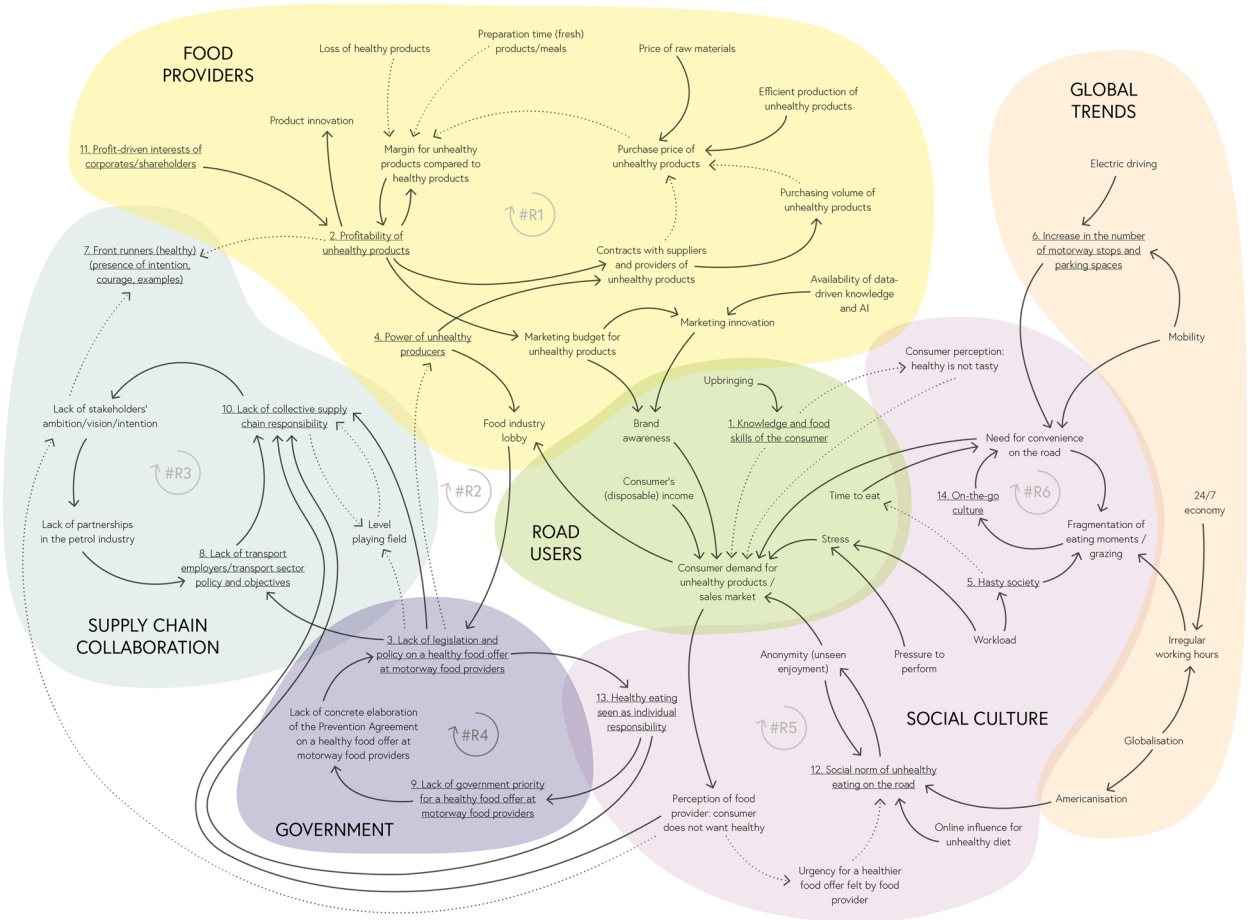

Fig. 1 Causal loop diagram shows the system that shapes the motorway food environment

partnerships within the petrol industry to address a healthier food environment collectively. As a result, there is minimal encouragement for the transport sector and transport employers to improve their policies for a healthier food environment, especially for truck drivers. Ultimately, this perpetuates a deficit in collective supply chain responsibility.

Subsystem 'government'

Government-related factors appear in the lower left side of the CLD in dark blue (Fig. 1). Besides the already mentioned cross-subsystem reinforcing feedback loop with the subsystem of the food provider (R2), an additional reinforcing feedback loop was found. This feedback loop was identified between this subsystem and the subsystem of social culture towards legislation and policies for a healthier motorway food environment (R4). This feedback loop indicates that the lack of legislation and policies on the healthiness of food offered at motorway food providers sustains a societal perspective where healthy eating continues to be seen as solely an individual's responsibility. As a consequence, there is a limited governmental emphasis on improving healthy food options at motorway food providers, which hampers the concrete elaboration of the NPA on healthy food offered at motorway food providers and in turn restricts progress in implementing legislation and policies regarding the health of food offerings in these environments.

Subsystem 'social culture'

Factors related to the social culture appear in the bottom/middle section of the CLD in pink (Fig. 1). Besides the cross-subsystem feedback loop (R4) already mentioned before, two reinforcing feedback loops within this subsystem were identified (R5 & R6). One cross-subsystem feedback loop (R5) appeared between this subsystem and the subsystem of road users and concerned perceptions of consumer preferences that shape unhealthy eating norms. This feedback loop shows that when food providers believe consumers prefer unhealthy options when on the road, food providers feel less urgency to offer healthier food alternatives, leading to a mostly unhealthy food

Table 1 Identified leverage point listed by level in the ASM model, subsystem, actions and their accompanying ASM level

Leverage point	ASM level	Subsystem	Actions	ASM level action
1. Insufficient knowledge and skills to make healthy food choices whilst on the road	Events	Road users	1. Develop and implement small incentives in the motorway food environment (e.g. wobblers/shelf cards) with inspiring and stimulating statements about healthy food, e.g. 'Have you already eaten 2 pieces of fruit?' or placing statements on healthy products: 'This is a healthy choice.'	Events
			2. Structurally include a healthy diet/lifestyle in the curriculum at schools so that children learn what healthy eating and drinking is	Structures
2. It is more attractive for food providers to offer unhealthy food products because they are more profitable than fresh, healthy food products	Structures	Food providers	3. Make the Netherlands Nutrition Centre's 'Food Environments Guideline' mandatory for all motorway food vendors (an ambition level can be set together, for example, 80% of the food offered is healthy)[a]	Goals
			4. Set up large-scale campaigns from producers to promote healthy choices and create awareness that healthy products are also tasty and available on-the-go	Events
			5. Develop handy, healthy, products with a long shelf life that are suitable for consumption 'on-the-go', to prevent loss as much as possible (e.g. healthy products that are gas-packaged and ready to heat on-site)[b]	Structures
3. Lack of government legislation and policy for a healthy motorway food environment	Structures	Government	6. Integrate criteria for a healthy food environment (e.g. food/beverage offer) in auctions of petrol stations by Rijkswaterstaat[c] (involving collaboration between the Ministry of Health, Welfare & Sport and Rijkswaterstaat)	Structures
			3. Make the Netherlands Nutrition Centre's 'Food Environments Guideline' mandatory for all motorway food vendors (an ambition level can be set together, for example, 80% of the food offered is healthy)[a]	*Goals*
4. Large and unhealthy food industries/chains have greater power than the smaller but healthier food industries	Structures	Food providers	7. Develop concrete objectives in collaboration with market leaders within the food industry to achieve a healthy food offer at motorway food vendors (e.g. XX% of the range is in the Dutch dietary guidelines, in addition to every product not in the Dutch dietary guidelines there is a healthier alternative offered)	Goals
			8. Monitor and benchmark the degree of health of the motorway food environment (e.g. based on a healthy food environment index). This benchmark can be used as a positive incentive (e.g. by identifying the frontrunners) or integrated into the corporate social responsibility (CSR) performance ladder	Structures
			9. Make it mandatory that promotions and communications only focus on healthy products when opening new stops[d]	Structures
5. In today's fast-paced society people experience a lot of haste, pressure and stress causing consumers to choose convenience products that are often unhealthy	Structures	Social culture	10. Design motorway stops as an 'oasis of tranquillity', for example with more greenery and seating areas	Structures
			11. Develop a campaign (e.g. SIRE[e]) to encourage people to take more time on the road to eat and not have to do everything in a hurry[f]	Events
6. The rise of electric driving and the increase of motorway stops has created opportunities for motorway convenience food vendors, favouring unhealthy easy-to-eat options	Structures	Global trends	12. Provide City Hubs[g] with healthy canteens or ensure that there is a healthy food offer near unloading and loading docks and charging points for drivers (with for example a 'healthy snack wall')	Structures
			13. Make 'a healthy food offer' a mandatory part of government permits for the rental of motorway food vendors	Goals
7. Lack of front runners offering healthy food at motorway stops	Structures	Supply chain collaboration	14. Put frontrunners of healthy motorway food vendors in the spotlight and support them (via media, subsidies, etc.)	Events
			15. Let the Collaborating Health Funds[h] play a role in communication with consumers to better visualise the frontrunners (the entire chain; from producer to consumer)	Events

Table 1 (continued)

Leverage point	ASM level	Subsystem	Actions	ASM level action
8. Lack of active pursuit by employers'organisations or industry associations in the transport sector regarding promoting healthy eating among employees	Structures	Supply chain collaboration	16. Submit ideas to employers to encourage a healthy diet among employees and facilitate employers financially, for example by making healthy eating affordable with a fuel card or subsidising a healthy meal	Events
			17. Make the benefits of healthy employees (i.e. less sick leave, more energy), the importance of a healthy diet and the role of working conditions insightful to employers	Beliefs
9. Lack of priority or concrete objectives by the government for creating a healthy motorway food environment	Goals	Government	18. Initiate a lobby from the sector for a more concrete policy from the government to create public outrage about the current food environment	Beliefs
			19. Encourage the setting of concrete objectives at the European level (including European Union-wide guidelines and incentives) to achieve a healthy motorway food environment throughout Europe	Goals
10. Lack of collective supply chain responsibility and ambition to take steps towards a healthier motorway food environment	Goals	Supply chain collaboration	20. Set up a steering group consisting of various parties throughout the supply chain to work together on a healthy motorway food environment, and thus implement the objectives of the Dutch National Prevention Agreement[i]	Structures
			21. Adapt the Netherlands Nutrition Centre's 'Food Environments Guideline' for the food offered at motorway food vendors for the entire chain (e.g. the shop of the future)	Structures
			22. Make chain-wide concrete (SMART) agreements and chain objectives about a healthy motorway food environment[d]	Structures
11. Profit and economic growth are the main objectives on which the motorway food environment is based	Goals	Food providers	23. Focus on product and process development within the entire chain, jointly (as a collective), for a healthier food offer	Goals
			24. Introduce various price measures that have been proven to be effective to encourage healthy eating (e.g. subsidies on fruit and vegetables) and to discourage unhealthy food choices (e.g. sugar and fat tax)	Structures
			25. Develop a pilot location 'healthy petrol station shop of the future'[d]	Events
			5. Develop handy, healthy, products with a long shelf life that are suitable for consumption 'on-the-go', to prevent loss as much as possible (e.g. healthy products that are gas-packaged and ready to heat on-site)[b]	*Structures*
			26. Make compensation available if companies have achieved goals or taken steps to create a healthier food environment[d]	Structures
12. It is the social norm to eat unhealthy food whilst on the road	Beliefs	Social culture	27. Work and implement the ambition described in the Dutch National Prevention Agreement, by, for example, developing and implementing concrete actions to realise a healthier food offer at motorway food vendors (such actions may include only having promotional deals on healthier options)	Structures
			28. Inform consumers about the healthiness of foods through various channels, for example via the Nutri-score at the point of purchase, or online via influencers	Events
13. The belief that making healthy food choices is an individual responsibility	Beliefs	Social culture	*20. Set up a steering group consisting of various parties throughout the supply chain to work together on a healthy motorway food environment, and thus implement the objectives of the Dutch National Prevention Agreement*[i]	*Structures*
			29. Identify opportunities in the market to realise a healthier food offer. For example, make an overview of all successful strategies that are applied (inter)nationally to realise a healthy food offer at motorway food vendors	Structures
			30. Make it mandatory to offer a 'healthy' alternative in addition to a product that is not in the Dutch dietary guidelines when setting up a new motorway stop[d]	Structures

Table 1 (continued)

Leverage point	ASM level	Subsystem	Actions	ASM level action
14. Society's shift away from traditional eating habits towards an on-the-go culture has normalised consuming convenient but unhealthy foods over healthier options, especially whilst traveling along motorways	Beliefs	Social culture	31. Create special healthy motorway stops with a healthier food offer of food and beverages, and where there is space to rest or relax	Structures
			11. Develop a campaign (e.g. SIRE[e]) to encourage people to take more time on the road to eat and not have to do everything in a hurry[f]	*Events*

[a] This is a combined action from leverage points 2 and 3

[b] This is an additional action (not part of the top two actions of the groups), mentioned by individual group members of both leverage points 2 and 11

[c] Rijkswaterstaat is a Dutch national institution that is responsible for the design, construction, management and maintenance of the Netherlands' primary infrastructure facilities

[d] This is an additional action (not part of the top two actions of the groups), mentioned by individual group members of this leverage point

[e] Stichting Ideële Reclame (SIRE) is a Dutch foundation that creates advertising campaigns on topics that the makers see as social problems

[f] This is a combined action from leverage points 5 and 14

[g] A central location storing all delivery products and goods destined for that region

[h] Collaborating Health Funds (in Dutch: Samenwerkende Gezondheidsfondsen) consists of 22 health funds that work to prevent, cure and treat diseases in the Netherlands

[i] This is a combined action from leverage points 10 and 13

supply that promotes unhealthy social eating norms at motorway stops. This normalisation, in turn, increases the acceptance of unhealthy and solitary eating among consumers at these stops, fostering a sense of anonymity and enjoyment unseen by their social network, whilst indulging in these unhealthy 'guilty pleasure' foods. Consequently, this reinforces the unhealthy eating social norm and strengthens the demand for unhealthy foods by consumers, further reinforcing food providers' perception that such options are preferred by consumers on the road. The other feedback loop concerned the fragmented eating trend that drives the demand for unhealthy food on-the-go (R6). This feedback loop suggests that as traditional eating habits, with three main meals, shift towards smaller, more frequent meals, an on-the-go eating culture is promoted. This leads to more food purchases made whilst traveling on motorways, where the available food is predominantly unhealthy. Consequently, the demand for convenient food that can be eaten quickly and easily on the road increases, thereby further fragmenting eating moments throughout the day.

Subsystems of 'road users' and 'global trends'

Factors related to road users appear in the middle of the CLD in green (Fig. 1). Factors related to global trends appear on the right side of the CLD in orange (Fig. 1). No feedback loops were identified within either of these subsystems.

Leverage points identified and actions proposed

As previously discussed, we identified fourteen leverage points and six feedback loops. Applying the ASM model, leverage points were predominantly positioned at the structures level ($n = 7$) of the system, followed by beliefs ($n = 3$), goals ($n = 3$) and events ($n = 1$) levels. The accompanying proposed actions to these leverage points are shown in Table 1.

Stakeholders identified a total of 35 actions based on the leverage points in the CLD. This included the two most contributing actions per leverage point and the other different actions identified during the group discussions as extracted by the field notes. However, four overlapping actions were merged, resulting in 31 unique actions. Among these, eight actions were categorised at the events level, sixteen actions at the structures level, five actions at the goals level and two actions at the beliefs level.

Five actions (#1, 2, 4, 11 and 28, see Table 1) specifically addressed the consumer to support them to make healthy choices. These included efforts to inform or educate the consumer about healthy choices (e.g. through school curricula or campaigns) or at the point of purchase (e.g. food labelling, shelf wobblers). Two actions (#16 and 17) targeted employers in the transport sector, aiming to inform them about the benefits of a healthy diet and the role of the working environment in healthy eating. One action also highlighted the potential for employers to provide financial support to drivers to encourage healthy food choices. Three actions (#7, 20, and 22) focused on the potential for collaboration within the sector to make agreements that would improve the food environment. Additionally, three actions (#5, 23 and 29) outlined the need for market opportunities for healthy product development, whilst four actions (#10, 12, 25 and 31) addressed the design of new concepts for creating 'healthy and de-stressing' petrol stations/

motorway stops. The need for actions to showcase front-runners appeared in two actions (#14 and 15). Four actions addressed the need for more concrete guidelines or actions for healthy environments along the motorway. These actions include the sector lobbying with the government to establish such guidelines (#18) as well as concretising ambitions set out in the NPA and the guidelines of the Netherlands Nutrition Centre, or the potential to establish concrete EU-level objectives (#19, 21 and 27). Two actions (#6 and 13) addressed the need to integrate healthy food environments into government permits or auctions for new motorway stops. Meanwhile, four actions (#3, 9, 24 and 30) focused on the need for mandatory regulations (such as food availability, prices and promotions) to improve the food offerings within food outlets at motorway stops. Finally, the need for monitoring and benchmarking the motorway food environment was set as an action (#8), and one action addressed the need for (financial) compensation if companies achieve the goals of healthy food environments (#26).

Discussion

This study identified the underlying systems dynamics contributing to the continued predominance of the unhealthy motorway food environment, as perceived by its stakeholders, including 52 interrelated factors across six interconnected subsystems with six reinforcing feedback loops. Additionally, 14 potential leverage points and 31 corresponding actions for change were identified at different systems levels (i.e. events, structures, goals and beliefs) [25]. This illustrates the complex nature of the motorway food environment and the need for a multifaceted approach to improve this environment. This should include a coherent set of actions, involving various stakeholders, and targeting different leverage points across all levels of the system. Such actions cannot be expected to yield immediate results; rather, they require a sustained, long-term commitment, supported by literature emphasising the necessity of a multi-decade timeline to effect systemic change [26, 27].

The analyses of the leverage points across different levels of the ASM model identified that the leverage points at the systems level of beliefs and goals were positioned within the 'food providers', 'supply chain collaboration', 'government' and 'social culture' subsystems. This highlights that the greatest potential for change lies beyond the individual consumer (e.g. the subsystem 'road user'). Moreover, the CLD also showed two general leverage points on the goal and belief level that are not unique to the motorway food environment but apply to all food environments. The first goal is the economic paradigm driving the motorway food environment. The CLD shows that the prioritisation of economic growth drives the profitability of unhealthy products over healthy ones due to lower production costs and higher profit margins (feedback loop R1) [17, 18, 28–31]. This was also observed in a study by Sawyer and colleagues that concluded that the unhealthy food environment is shaped by an economic paradigm in which multiple subsystems collectively make unhealthy foods highly accessible, available and affordable [18]. Such a profit-driven system empowers the food industry with influential lobbying to promote their interests, which inherently increases their power, often in contrast to public health interests [32]. Second, the belief that food choices are an individual responsibility is present in the CLD (feedback loop R4). This belief is a driving force behind the lack of priority and implementation of legislation and policy on a healthy food offer at motorway food providers. Stakeholders also addressed that the lack of collective responsibility within the supply chain (feedback loop R3) was related to the ideology of individual responsibility. This belief has also been acknowledged in the literature [33–35]. To illustrate, a previous GMB study on obesity prevention policy decision-making indicated that policies were often framed to align with decision-makers' beliefs, which were often based on predominant neoliberalist ideologies [36]. Thus, achieving meaningful change in poor food environments requires a societal shift that prioritises public health over profit, recognising the profound impact of environmental factors on individual behaviour. Yet, it is known that these high-impact leverage points are often the most difficult to change as they require shifts in deeply rooted goals and beliefs that shape the food environments consumers interact with [25].

In addition to these general leverage points, the results also highlight two additional high-impact leverage points that are particularly evident in the on-the-go setting, including the motorway food environment, emphasising its impersonal and convenience-driven characteristics. First, the CLD highlights food providers' beliefs about consumer preferences for unhealthy foods, which are reinforced by the anonymity of motorway stops, where individuals may often feel free to indulge without judgement (feedback loop R5). Second, the CLD underscored the belief that a fast-paced society drives an on-the-go culture, leading to more fragmented eating moments ('grazing'), which is evident in the motorway context (feedback loop R6). Whilst the rise of an on-the-go culture has been a broader societal trend [37], its effects are likely more pronounced in on-the-go settings, including the motorway food environment, where on-the-go consumption and quick-service are integral to the setting [11]. These observations align

with previous research indicating that economic pressures, such as longer working hours and limited personal time, have fuelled the rise of an on-the-go culture that prioritises convenience [38]. This emphasises the need for a comprehensive analysis of the food environment in specific settings for effective interventions, as one-size-fits-all strategies fail to address the complexities of diverse contexts.

Actions formulated by the participating stakeholders appeared across all levels of the system, with only eight of the 31 actions formulated at the lower events level. This is a positive outcome and illustrates the value of the GMB methodology, which stimulates actions at mutually reinforcing levels of the ASM [25]. The actions identified also differ from many healthy eating policies and actions, as they are primarily focused on events level actions. These actions are often ineffective in improving healthier population diets and have little leverage for systemic change [25]. This does not necessarily mean that the actions identified at the events level are unimportant, as they could be stepping stones to more systemic changes [25]. However, additional efforts are required, particularly in also addressing the beliefs, goals and structures of the motorway food environment system. Although the participants succeeded in formulating actions at the highest levels of the ASM (with fewer targeting the goals and beliefs levels), most efforts were concentrated at the structures level. This is in line with prior studies, where participants struggled to generate actions aimed at the goals and beliefs level of the system [39, 40]. To identify actions aimed at the deepest levels of the system, previous research suggested that it is important to invite high-level representatives who have the leverage to mobilise resources and build capacity to change higher levels in the system [27, 40]. We attempted to include high-level representatives such as food producer directors. However, they may not have provided the high level of representation needed, and the additional involvement of shareholders from the participating companies was likely necessary. Another explanation could be that one workshop to formulate actions is not enough. As previous research has suggested, the inability to form actions on deeper levels was likely due to insufficient time being allocated to the process [39].

Although the actions were developed by stakeholders during the second workshop, several align with prior research into optimising food environments in general, or in different contexts. To illustrate, several actions focused on mandatory regulations either to improve the food offerings within food outlets at motorway stops (e.g. food availability, prices and promotions) or enforce contracts for permits of stopping places that require healthy food options. The need for mandatory actions to improve food environments aligns with previous research in retail and food vendor settings, as well as for national regulations, that argue that these mandatory actions improve purchasing, dietary intake and health at population level [41–43]. To illustrate, one of the proposed mandatory policies are various price measures to discourage unhealthy food choices (e.g. sugar and fat tax). Indeed, findings from a systematic review on the effect of a sugar-sweetened beverage (SSB) tax found that it was effective in reducing SSB purchases and dietary intake [43]. Besides these mandatory regulations, several proposed actions addressed the role of the petrol branch and the food industry in improving the food environment. Some of these actions, including food reformulation, can improve nutrient intake [44]. However, it is also known that voluntary industry-led efforts have thus far been insufficient in driving substantial improvements in the food environment, highlighting the need for mandatory regulations on these various actions [45, 46]. Similarly, the NPA consists solely of voluntary measures for healthy food environments, resulting in minor improvements and a limited impact on slowing the rise of overweight and obesity [47]. Finally, actions addressed individuals or employers to support their employees to make healthy choices, including efforts to inform or educate them to make healthier choices. Whilst education about healthy food is indeed important (e.g. as part of the curriculum at schools, #2 Table 1), such measures alone are inadequate to improve population diets, and require implementation in conjunction with other strategies [41, 48]. This underscores the need for a systems approach in which these measures are collectively integrated [49]. Whilst this discussion does not encompass all actions developed by the participants in our study, they illustrate the potential impact of the stakeholders' proposed actions in promoting healthier food choices. However, the implementation and effectiveness of particular actions, such as the integration of healthy food regulations into government permits or auctions for new motorway stops remain scarce and warrant further research [50].

Strengths and limitations

A strength of the study was the large ($n = 36$ (workshop 1) and $n = 38$ (workshop 2)) and varied group of stakeholders that participated in this study. This resulted in

a wide variety of viewpoints that could be considered in this study. Moreover, predefined scripts were used to systematically develop the CLD underlying the continued predominance of the unhealthy motorway food environment [21]. However, the study also has several limitations. Firstly, whilst we strived to include as many different stakeholder groups as possible, unfortunately, some were either hard to reach or cancelled their participation last minute. Therefore, only one supplier participated and experts in infrastructure and planning were absent. Consequently, the absence of some stakeholders meant that not all perspectives were included. Furthermore, as the CLD represents the Dutch stakeholders' perspectives and experiences, it is therefore not directly generalisable, especially outside the Dutch motorway context. Lastly, the leverage points were identified by the research team, which could have led to researcher bias which potentially could have led to a skewed or limited understanding of the system.

Implications for research, policy, and practice

Since the CLD is based on stakeholder views, future research could ground and supplement the CLD and determine whether these results remain valid based on prior insights from the literature. Furthermore, further research could evaluate the implementation of actions to improve the motorway food environment as well as food purchases of road users. Although none of the actions identified have been implemented so far, some have been implemented in comparable settings. Public health professionals could explore how these actions can be consolidated into a broadly supported, multidimensional action plan and identify what is needed to adapt and implement them in this specific setting. Moreover, creating a level playing field for front runners of healthy food offerings can contribute to reducing the profit-driven paradigm together with other steps such as working towards a system where health is the outcome of the system instead of profit. Therefore, future research and policy should explore how to incentivise front runners to introduce healthier options without suffering significant financial setbacks. Possible strategies include subsidies or tax incentives to balance the ratios of unhealthy to healthy food options for motorway food providers.

Conclusions

These findings show that there are many interrelated factors and mechanisms contributing to the continued predominance of the unhealthy motorway food environment. Actions for change were proposed together with stakeholders aimed at different leverage points at different levels of the system. The results show that the motorway food environment is shaped by broader societal goals and beliefs (e.g. the profitability of unhealthy products) and social-cultural beliefs particularly evident to the on-the-go setting, including the motorway food environment (e.g. on-the-go culture). Together, they present the strongest potential for leveraging systems change. The need for a coherent multidimensional action plan targeting these leverage points with actions at all system levels, which is broadly supported by various stakeholders, is emphasised to change the system underlying the continued predominance of the unhealthy motorway food environment.

Abbreviations

ASM	Action Scales Model
CLD	Causal Loop Diagram
GMB	Group Model Building
NCD	Noncommunicable disease
NPA	National Prevention Agreement
SEC	Social Sciences Ethics Committee
STICKE	Systems Thinking In Community Knowledge Exchange

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12916-025-04088-w.

Additional file 1. Description of workshop activities. A detailed programme and description of research activities during the two GMB workshops performed.

Additional file 2. Description and attendance of participants of the two Workshops. A list of anonymised attendance of participants of the two Workshops, based on stakeholder group and job position.

Acknowledgements

We would like to thank all participants for their valuable contribution to this study. We also appreciate Kathelijne Bottema and the Netherlands Nutrition Centre for their support in participant recruitment. Our thanks go to Tamika Wopereis, Joline Wierda and Ward van Hoeven for their assistance during the workshops. Finally, we would like to express our gratitude to Anne Zeegers of PlaatPraters for designing the CLD figure.

Authors' contributions

LG, CD, FR, SD and MP designed the study. LG oversaw the data collection and led the data analysis with contributions from CK, FR, SD and MP. LG, CD, FR, SD, FR and MP assisted in data interpretation. LG wrote the manuscript and all authors provided input and feedback and edited the manuscript. All authors read and approved the final manuscript.

Funding

The research described in this paper was financially supported by Regio Deal Foodvalley (grant no. 162135). This is a collaboration between the Dutch government, the provinces of Utrecht and Gelderland, eight local municipalities, educational and knowledge institutions and entrepreneurs within this region [19]. Regio Deal Foodvalley had no role in the design, analysis or writing of this article.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving research study participants were approved by the Social Sciences Ethics Committee (SEC) of Wageningen University (approval number: 2023–17-Geboers). Written informed consent was obtained from all the participants. Additionally, participation was anonymous and non-invasive.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Chair Group Consumption and Healthy Lifestyles, Department of Social Sciences, Wageningen University & Research, Wageningen 6706 KN, The Netherlands. [2]Public and Occupational Health, Amsterdam UMC, location Vrije Universiteit Amsterdam, Boelelaan 1117, Amsterdam, Netherlands. [3]Amsterdam Public Health Institute, Amsterdam, The Netherlands.

Received: 5 December 2024 Accepted: 24 April 2025
Published online: 13 May 2025

References

1. World Health Organization. Obesity and overweight. (n.d.). https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Accessed 9 Dec 2021.
2. World Health Organization. Noncommunicable diseases. (n.d.). https://www.emro.who.int/noncommunicable-diseases/causes/unhealthy-diets.html. Accessed 14 Feb 2024.
3. Willet W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, et al. Food in the anthropocene: the EAT–lancet commission on healthy diets from sustainable food systems. Lancet. 2019;393(10170):447–92.
4. Swinburn B, Friel S, Hawkes C, Kelly B, Lee A, Ma J, et al. INFORMAS (International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support): overview and key principles. Obes Rev. 2013;14:1–12.
5. McGuirt JT, Huebner G, Ward R, Pitts SBJ. Food and beverage options at highway rest areas in North Carolina: A mixed-methods audit and geospatial approach. Prev Chronic Dis. 2019;16(10):E42
6. Apostolopoulos Y, Lemke M, Sönmez S, Hege A. The obesogenic environment of commercial trucking: a worksite environmental audit and implications for systems-based interventions. Am J Health Educ. 2016;47(2):85–93.
7. Lincoln JE, Birdsey J, Sieber WK, Chen GX, Hitchcock EM, Nakata A, et al. A pilot study of healthy living options at 16 truck stops across the United States. Am J Health Promot. 2018;32(3):546–53.
8. Houghtaling B, Balis L, Minaker L, Kheshaifaty K, Morgan R, Byker SC. A systematic review of trucking food, physical activity, and tobacco environments and tractor-trailer drivers' related patterns and practices in the United States and Canada, 1993–2021. Prev Med Rep. 2022;26:2211–3355.
9. Reinders M, van Haaster-de Winter MA, van den Berg I, Bakker J. Opportunities for sustainable eating on the go. 2012. https://edepot.wur.nl/205487. Accessed 4 Dec 2024.
10. National Government. The National Prevention Agreement. A Healthier Netherlands. 2019. https://www.government.nl/documents/reports/2019/06/30/the-national-prevention-agreement. Accessed 16 Jan 2023.
11. Lemke MK, Houghtaling B, Winkler MR, Hege A. Rethinking efforts to improve dietary patterns among long-haul truck drivers: transforming truck stop retail food environments through upstream change. Am J Health Promot. 2023;37(6):755–9.
12. Luna Pinzon A, Waterlander W, de Pooter N, Altenburg T, Dijkstra C, Emke H, et al. Development of an action programme tackling obesity-related behaviours in adolescents: a participatory system dynamics approach. Health Res Policy Syst. 2024;22(1):30.
13. Mui Y, Ballard E, Lopatin E, Thornton RLJ, Pollack Porter KM, Gittelsohn J. A community-based system dynamics approach suggests solutions for improving healthy food access in a low-income urban environment. PLoS One. 2019;14(5):e0216985.
14. Luna Pinzon A, Stronks K, Dijkstra C, Renders C, Altenburg T, den Hertog K, et al. The ENCOMPASS framework: a practical guide for the evaluation of public health programmes in complex adaptive systems. Int J Behav Nutr Phys Act. 2022;19(1):33.
15. Hovmand PS. Introduction to Community-Based System Dynamics. In: Community Based System Dynamics. Springer, New York, NY; 2014. p. 1–16.
16. Baugh Littlejohns L, Hill C, Neudorf C. Diverse Approaches to Creating and Using Causal Loop Diagrams in Public Health Research: Recommendations From a Scoping Review. Public Health Rev. 2021;42: 1604352.
17. Karapici A, Cummins S. A participatory approach to model the neighbourhood food environment. PLoS One. 2024;19(1):e0292700.
18. Sawyer ADM, van Lenthe F, Kamphuis CBM, Terragni L, Roos G, Poelman MP, et al. Dynamics of the complex food environment underlying dietary intake in low-income groups: a systems map of associations extracted from a systematic umbrella literature review. Int J Behav Nutr Phys Act. 2021;18:1–21.
19. Regiodeal Foodvalley. Regiodeal Foodvalley; About us. . (n.d.). https://www.regiofoodvalley.nl/over-ons. Accessed 20 Sep 2022.
20. Bourne L, Weaver P. Mapping Stakeholders. In: Chinyio E, Paul Olomolaiye P, editors. Construction stakeholder management. Oxford: Wiley-Blackwell; 2010. p. 99–120.
21. Hovmand PS, Rouwette E, Andersen DF, Richardson GP, Calhoun A, Rux K, et al. Scriptapedia: A Handbook of Scripts for Developing Structured Group Model Building Sessions. 2011. http://hdl.handle.net/2066/95406. Accessed 16 Jan 2024.
22. Deakin University. STICKE 3 [Software]. (n.d.). https://sticke.deakin.edu.au. Accessed 5 Dec 2024.
23. Heemskerk DM, Busch V, Piotrowski JT, Waterlander WE, Renders CM, van Stralen MM. A system dynamics approach to understand Dutch adolescents' sleep health using a causal loop diagram. Int J Behav Nutr Phys Act. 2024;21(1):34.
24. Meadows D. Places to intervene in a system. Whole Earth. 1997;91(1):78.
25. Nobles JD, Radley D, Mytton OT. The action scales model: a conceptual tool to identify key points for action within complex adaptive systems. Perspect Public Health. 2022;142(6):328–37.
26. Leeuwis C, Boogaard BK, Atta-Krah K. How food systems change (or not): governance implications for system transformation processes. Food Sec. 2021;13(4):761–80.
27. Public Health England. Whole systems approach to obesity: A guide to support local approaches. 2019. https://www.gov.uk/government/publications/whole-systems-approach-to-obesity. Accessed on 13 Nov 2024.
28. Luna Pinzon A, Stronks K, Emke H, van den Eynde E, Altenburg T, Dijkstra SC, et al. Understanding the system dynamics of obesity-related behaviours in 10- to 14-year-old adolescents in Amsterdam from a multi-actor perspective. Front Public Health. 2023;11:1128316.
29. Chavez-Ugalde Y, Jago R, Toumpakari Z, Egan M, Cummins S, White M, et al. Conceptualizing the commercial determinants of dietary behaviors associated with obesity: A systematic review using principles from critical interpretative synthesis. Obes Sci Pract. 2021;7(4):473–86.
30. De Lacy-Vawdon C, Livingstone C. Defining the commercial determinants of health: a systematic review. BMC Public Health. 2020;20:1–6.
31. West R, Marteau T. Commentary on Casswell (2013): the commercial determinants of health. Addiction. 2013;108(4):686–7.
32. Djojosoeparto S. Government policies to improve food environments: A population and equity lens [Doctoral dissertation,]. Utrecht: Utrecht University; 2023.
33. Mata J, Hertwig R. Public beliefs about obesity relative to other major health risks: Representative cross-sectional surveys in the USA, the UK, and Germany. Ann Behav Med. 2018;52(4):273–86.
34. Saito J, Odawara M, Takahashi H, Fujimori M, Yaguchi-Saito A, Inoue M, et al. Barriers and facilitative factors in the implementation of workplace health promotion activities in small and medium-sized enterprises: a qualitative study. Implement Sci Commun. 2022;3(1):23.
35. Bayer S, Drabsch T, Schauberger G, Hauner H, Holzapfel C. Responsibility of Individuals and Stakeholders for Obesity and a Healthy Diet: Results From a German Survey. Front Psychiatry. 2020;11: 616.

36. Clarke B, Kwon J, Swinburn B, Sacks G. Understanding the dynamics of obesity prevention policy decision-making using a systems perspective: A case study of Healthy Together Victoria. PLoS One. 2021;16(1):e0245535.
37. Benoit née Moeller S, Schaefers T, Heider R. Understanding on-the-go consumption: Identifying and quantifying its determinants. J Retail Consum Serv. 2016;31:32–42.
38. Lim WM, Das M, Saha V. From consuming food away from home to on-the-go consumption: a multi-study exploration using focus groups and fsQCA. J Mark Manag. 2025;41:1–45.
39. Gerritsen S, Renker-Darby A, Harré S, Rees D, Raroa DA, Eickstaedt M, et al. Improving low fruit and vegetable intake in children: Findings from a system dynamics, community group model building study. PLoS ONE. 2019;14(8): e0221107.
40. Wopereis TM, Dijkstra C, Wierda JJ, Rongen FC, Poelman MP. Systems thinking for local food environments: a participatory approach identifying leverage points and actions for healthy and sustainable transformations. Health Res Policy Syst. 2024;22(1):101.
41. Mah CL, Luongo G, Hasdell R, Taylor NGA, Lo BK. A Systematic Review of the Effect of Retail Food Environment Interventions on Diet and Health with a Focus on the Enabling Role of Public Policies. Curr Nutr Rep. 2019;8:411–28.
42. Hillier-Brown FC, Summerbell CD, Moore HJ, Routen A, Lake AA, Adams J, et al. The impact of interventions to promote healthier ready-to-eat meals (to eat in, to take away or to be delivered) sold by specific food outlets open to the general public: a systematic review. Obes Rev. 2017;18(2):227–46.
43. Teng AM, Jones AC, Mizdrak A, Signal L, Genç M, Wilson N. Impact of sugar-sweetened beverage taxes on purchases and dietary intake: Systematic review and meta-analysis. Obes Rev. 2019;20(9):1187–204.
44. Gressier M, Swinburn B, Frost G, Segal AB, Sassi F. What is the impact of food reformulation on individuals' behaviour, nutrient intakes and health status? A systematic review of empirical evidence. Obes Rev. 2021;22(2): e13139.
45. Packer J, Michalopoulou S, Cruz J, Dhar D, Stansfield C, Kaczmarska H, et al. The impact of non-fiscal mandatory and voluntary policies and interventions on the reformulation of food and beverage products: a systematic review. Nutrients. 2024;16(20): 3484.
46. Moodie R, Stuckler D, Monteiro C, Sheron N, Neal B, Thamarangsi T, et al. Profits and pandemics: prevention of harmful effects of tobacco, alcohol, and ultra-processed food and drink industries. Lancet. 2013;381(9867):670–9.
47. Djojosoeparto SK, Kamphuis CBM, Vandevijvere S, Poelman MP. How can national government policies improve food environments in the Netherlands? Int J Public Health. 2022;67:1604115.
48. Meiklejohn S, Ryan L, Palermo C. A systematic review of the impact of multi-strategy nutrition education programs on health and nutrition of adolescents. J Nutr Educ Behav. 2016;48(9):631-646.e1.
49. Lee BY, Bartsch SM, Mui Y, Haidari LA, Spiker ML, Gittelsohn J. A systems approach to obesity. Nutr Rev. 2017;75:94–106.
50. Wopereis TM, Djojosoeparto SK, Rongen FC, Peeters SC, de Vet E, Poelman MP. Temptation at every corner: exploring public perceptions of food cues and policy support for governmental food cue regulation in outdoor public spaces. BMC Med. 2024;22(1):602.

Publisher's Note