Taking a Broad Societal Perspective to the Prevalence of Type-2 Diabetes in the Netherlands: Mapping and Simulating Feedback by Applying System Dynamics & Group Model Building

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Abstract

The increasing prevalence of type-2 diabetes in the Netherlands comes hand in hand with rising costs, inequality between social groups, and a lower quality of life for those affected and at risk for developing it in the future. By clustering knowledge about the issue from domain experts and practitioners into a conceptual systems map, and using illustrative simulation for parts of the system, we facilitated insights into hypothetical effects of policy in future scenarios. during Group Model Building sessions. It was reasoned that partnerships between employers and research can potentially be most beneficial, thanks to their interaction, resulting in greater availability and usability of data, in less time.

Introduction

The increasing prevalence of type-2 diabetes in the Netherlands comes hand in hand with rising costs, inequality between social groups, and a lower quality of life for those affected and at risk for developing it in the future. In contrast with past interventions, this early research program applied systems thinking and simulation together with stakeholders to assess the capability of these methods in finding better long-term solutions with greater impact. A systems approach is found necessary for a more integrated way of thinking, to provide insights on how chronic diseases are related to lifestyle and environment (van Wietmarschen, Wortelboer, & van der Greef, 2018). The prevalence of type-2 diabetes, and interventions to reducing it, are closely related with lifestyle, thus insights following from this approach are reasoned to be potentially generalisable to other types of lifestyle diseases as well (Molema, van Erk, van Winkelhof, van't Land, & Kiefte-de Jong, 2019). As part of TNO's Complexity Program "Grip on Health", a team committed to developing policy advice by simulation applied Group Model Building (GMB) and System Dynamics (SD) to the type-2 diabetes issue (NIDDK, 2018; Richardson, 2011; Vennix, 1996). GMB and SD are used as a method which helps policy makers to understand complex issues involving different groups of stakeholders and institutions, and has found to be useful in similar issues (Homer, Hirsch, Minniti, & Pierson, 2004; Hovmand, 2014; Stroh, 2015). By clustering knowledge about the issue from domain experts and practitioners into a conceptual systems map, and using illustrative simulation for parts of the system, we facilitated insights into hypothetical effects of policy in future scenarios.

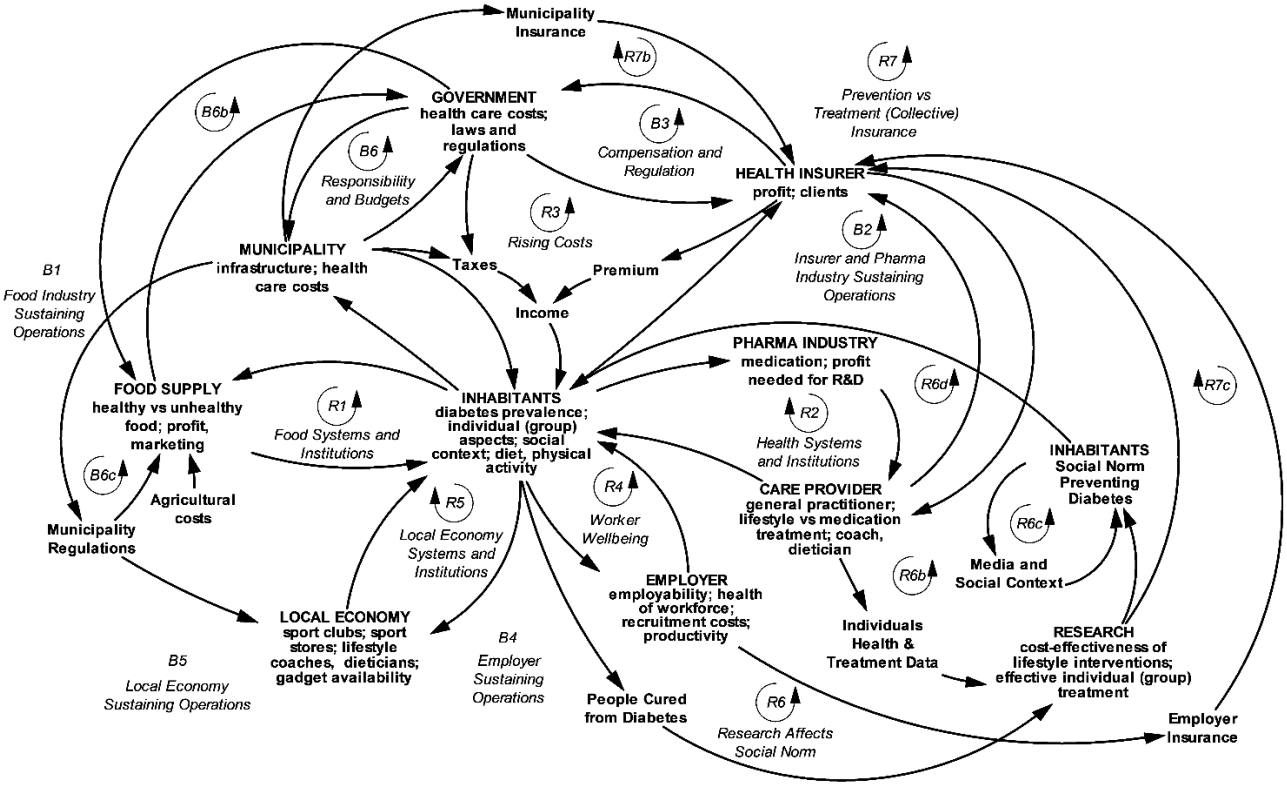
To assess the potential of GMB and SD to be applied to a larger research program focused on type-2 diabetes prevention in Amsterdam, a two-month pilot project has been organized. DynaMundo assisted TNO with designing and facilitating the workshops and with the system dynamics modeling. The workshops were attended by experts and practitioners from TNO, the AMC (Amsterdam Medical Centre) and the GGD Amsterdam. Some participants were asked to take on the role of real-life stakeholders, while others represented their own position. Through the workshop, a systems map was created based on the expertise of the participants. Additionally, some initial experiments have been performed with quantifying the model.

The main outcome of the workshops is a conceptual systems map (see Figure 1), which gives a high-level overview of how different stakeholders and institutions are part of an interconnected system

that has an impact on the likelihood that urban residents will develop type-2 diabetes. Participants had expertise on different parts of the system, and they acknowledged that the group-based modeling helped them to gain a shared understanding about the issue and a common language to discuss it. The experimental simulations, furthermore, provided a first glimpse of how the model could help to evaluate the effectiveness of different kinds of interventions. The participants acknowledged, however, that more research and data is needed before conclusions can be made.

Dynamic Hypothesis

The high-level overview of the conceptual systems map (see Figure 1) was built step-by-step together by the participants and the facilitator during the three four-hour sessions, by which it has been useful as a shared understanding and language in discussing the development of type-2 diabetes. Currently it provides a visual summary of topics discussed during the sessions, as well as their high-level relations and feedback structures (the origins of these feedback loops, including link polarities and stock-flow structures, can be found in the appendices).



Legend

INHABITANTS diabetes prevalence; individual (group) aspects; social context; diet, physical activity	Stakeholders identified are in Capital-letter words. Underneath are factors frequently mentioned during the discussion that suggest more specific system elements.
Food Systems and Institutions	R and B indicate assumed reinforcing and balancing feedback loops and are accompanied by an illustrative name written in italic beneath it.
	Reinforcing feedback loops are potential accelerating forces, through self-driven growth or decline. The numbers represent single-, or clusters of feedback effects
	Balancing feedback loops indicate possible counteracting or limiting forces, through desired states or goals or systemic limitations.
B1	Non-apparent loop icons indicate that no relations are mapped, but an assumed feedback effect is present.

Figure 1. High-level overview of societal feedback structures in the prevalence of T2D

Description of Feedback Loops

The following paragraphs provide examples of possible dynamic behaviour that could result from feedback loops. As a guide to the reader five feedback loops are described in this section. All verbal descriptions and discussion considering the feedback loops in Figure 1 appear in the transcripts of the sessions.

Food Systems and Institutions

The reinforcing feedback loop, R1: “Food Systems and Institutions”, can be described by the vicious or virtuous developments of the interaction between the Food Supply domain and the Inhabitants. (food related mapping was mainly inspired by work by Struben, Chan, & Dubé, 2014, 2018). For example, when inhabitants would consume more of the products containing higher amounts of sugar, the profit from those products increases. When it is noticed that those products are liked, or that more profit is generated by those products, producers and retailers could increase the marketing efforts, in the hope that even more people would buy those products, or that the same inhabitants consume more. A similar dynamic could occur when the sales of products are decreasing, leading to a decrease in marketing effort, and eventually resulting in even less sales than would otherwise be the case. Moreover, vicious or virtuous developments can be the case for different product types, both healthy and unhealthy ones.

Food Industry Sustaining Operations

The symbol for the balancing loop B1, called “Food Industry Sustaining Operations”, is shown in the high-level overview to remind the observer that producers and retailers are acting within limitations or can counteract certain developments. For example, when sales fall from products of which the sales are expected to be easily influenced by marketing efforts, producers or retailers could decide for new marketing campaigns, which could boost the sales of those products. When the sales of those product groups grow, it might not be perceived to be necessary to keep on the marketing efforts. Next to that, when overall profit falls due to competition, or to changing demands of consumers, producers and retailers could invest in research and development to find better or new products that appeal to the consumers. The limitations of food producers and retailers are in the sense of the expectations, knowledge and financial means that they have at a certain moment in time, which can often counteract efforts to reduce the onset of type-2 diabetes.

Compensation and Regulation

The balancing feedback loop B3 between the government and insurers, named "Compensation and Regulation", symbolizes the push and pull behaviour between the health care insurance law (Zorgverzekeringswet), and the need for health care. Insurers could ask the government to provide funds, and the legal basis for a greater variety of healthcare services. Based on predictions of the necessary amounts and effects these funds could be created and the law adjusted, which provides insurers the possibility to cover those services. Wen these services are shown to be more costly or less effective than is predicted, the government could decide to take away or limit the budget and legal basis for those services, reducing the service that insurers can provide, which might affect their income. This could in turn be reason for insurers -also together with health providers and the pharmaceutical industry- to seek other profitable and effective ways for providing care, which in turn are discussed with the government.

Rising Costs

The "Rising Costs" reinforcing feedback loop R3 symbolizes the causal effects between the costs of healthcare and the ability to be healthy. It is reasoned that rising costs of healthcare, both for insurers, the government and municipalities, could result in an increase of taxes and premium, reducing the overall income of the inhabitants. A healthy diet and the possibility for exercise is currently often costly, such that with a lower income it is harder to easily exercise or buy healthy food products. Over years, a less healthy diet and lower level of exercise increase the possibility for health problems, resulting in earlier symptoms, and more costly care over years. In turn, rising healthcare costs are even further pressing budgets with the government, municipalities and insurers, who could raise taxes, resulting in a lower income than would otherwise be the case, and thus a lower ability to live healthy than in the case taxes would not have increased. This does not necessarily mean that the ability to live healthy decreases, but that the pace in which the ability increases is slower than could otherwise be the case.

Responsibility and budgets

The " Responsibility and budgets" self-correcting effect B6 indicates the interaction between national and local government on the responsibility and costs of healthcare. Recently, responsibility has changed towards local governments. Besides, governments have influence on and are influenced by food corporations (loop B6b). The awareness of possibilities for change and the feeling of responsibility can provide for regulations. Similar dynamics play a role in regional and local governments, depicted by municipality regulations and loop B6c.

Research Affects Social Norm

R6, the “Research Affects Social Norm” loop, describes the available evidence and ideas about curing and preventing type-2 diabetes. It is reasoned that some of whom are cured from type-2 diabetes are part of research programs, relying on data from health providers and from the patient. When research comes to clear, undebated conclusions, this information diffuses to the public, often over a long time, which can change the ‘social norm’. The social norm is used to indicate the awareness of the inhabitants about the long-term effects of diet and exercise. When the social norm changes with more patients, and more patients are cured from type-2 diabetes, this results in more cases for research, and more evidence on best practices. Data availability (R6b) can reinforce the effect that research findings have on a healthy lifestyle, which can generate even more evidence and nuances to the specific research area. Together with the increasing availability and usability of data, this could contribute to a reinforcing feedback loop, in which research is a main driver in changing the social norm and reducing the prevalence and onset of type-2 diabetes. Different social groups influence themselves and each-other through the social contexts and (social) media (R6c). Certain types of lifestyles can spread through a subgroup or between subgroups, changing established (cultural) norms. The changed social norms can, on in the long term, affect the prevalence of T2D and other types of lifestyle related diseases (R6d), of which the word-of-mouth and awareness itself can be reinforcing.

Prevention vs Treatment (Collective) Insurance

This dynamic is illustrative for the possibilities that municipalities and employers have in insurance for healthcare. Insurance is increasingly more aware of the potential of providing care on the preventive side, geared towards lifestyle, instead of being more reactive and treating symptoms or diseases once these are there. R7b indicates that municipalities are involved with certain types of insurance to people with disabilities. When care is provided before the onset of T2D, or can delay or

reverse the effects of T2D, a reinforcing effect is in play by which more funds are available on the preventive side than would otherwise be the case. A similar dynamic occurs with health insurance provided by employers (loop R7c).

Analysis

Based on diagrams from sessions one and two (see appendices), an explorative model was developed of which simulations were shown and discussed in sessions 2 and 3. The purpose was to provide an idea of the contributions from simulations on future policy scenarios, to facilitating policy design and the expectations to long-term effects. The model developed was not based on real data, and used to show how simple stock and flow models (also see the supplementary material) can provide an impression of the types of behaviour that can result from three feedback loops identified by stakeholders during the workshops:

- R4 - the reinforcing 'Worker Wellbeing' loop - indicating the following effect: what if employers invest in the wellbeing of their employees, improving their productivity, which increases profits and raise the budget for the wellbeing of employees?
- B2 - the balancing 'Pharma Industry Sustaining Operations' loop - indicating the following effect: what if the number of people suffering from diabetes and using medication decreases, or is lower than would otherwise be the case, and the pharma industry decides to increase marketing and lobby efforts for the awareness about the positive effects of medication?
- R6 and R6b - the reinforcing 'Research Affects Social Norm' loop - indicating the following effect: what if investments in research lead to scientific publications, which raises awareness and by doing so affects social norms, consequentially increasing physical activity and improving diet?

The model includes levers to interact with leverage points governing the strengths of these three feedback loops. Numbers are not based on research and are purely hypothetical what-if scenarios to spark discussion. This showed the possibility of making comparisons amongst scenarios, which provoked new discussion for how certain policies work and how fast effects could be expected. Thereby facilitating greater insight in long term effects and different types of policy interventions and venues for research.

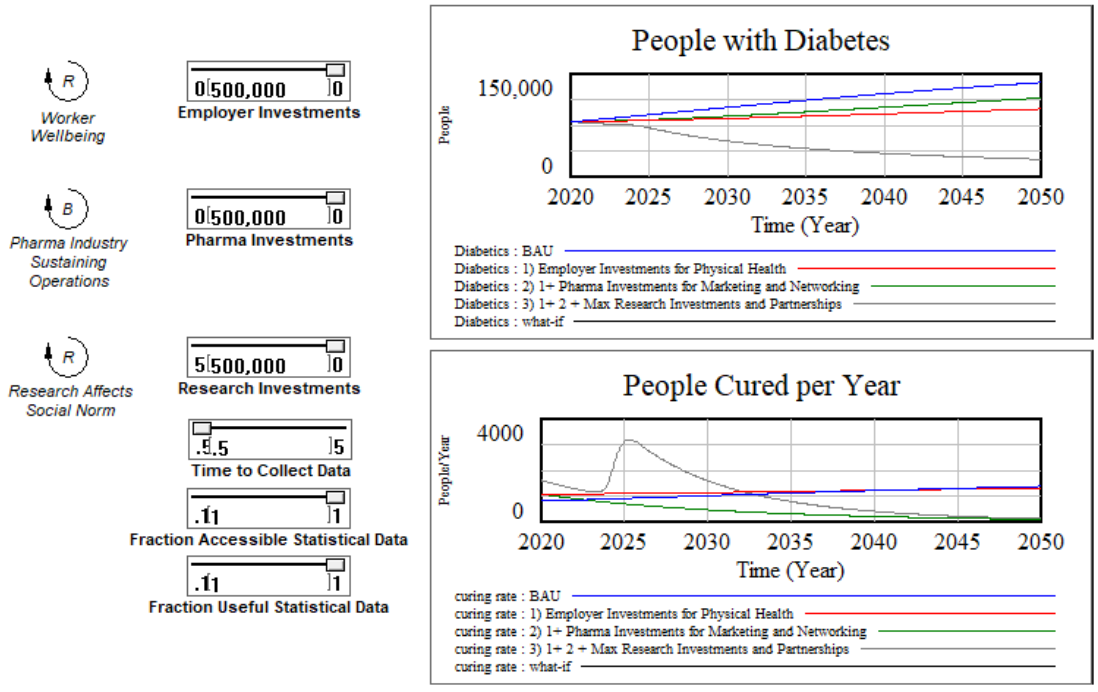


Figure 2. Impression of different scenario settings

Currently investments prevail in this user interface. However, profits were reasoned to increase, and costs to decrease when people become healthier in the future. Estimating the probability of these savings would be a topic for future research. It was reasoned that pharma investments could slow the pace of the transition away from medication, even though employers would make investments (scenario 2, including pharma investments and employer investments, results in more people with diabetes and a smaller number of people cured per year than scenario 1). Scenario 3 includes the 'Research Affects Social Norm' factors with the most favourable settings, and the Employer Investments set to maximum. Based on the discussions around these simulated scenarios it was reasoned that partnerships between employers and research can potentially be most beneficial thanks to their interaction resulting in greater availability and usability of data in less time. The full documentation of the model is available through the supplementary material.

Discussion and Limitations

Participants acknowledged that the group-based modeling helped them to gain a shared understanding about the issue and a common language to discuss it. There have no questionnaires been taken before, during or after the session. Future research could include short questionnaires to see changes in mental models and appreciations of the problem that occurred with participants and included stakeholders.

The differences between social groups have been explored during the discussions, however, these have not been explicitly included in the diagrams or scenario's in this report. Future research might include scripts for eliciting arrays to the model, and couple this with descriptions of the social group in terms of 'persona's'. Descriptions of persona's can represent an 'average' of the social group, whilst the description can still be loosely based on the available information of that group. During the iterative process of literature research, constructing the dynamic hypothesis, and calibration to data, these persona's can be revised, and the mental models that were associated with the social groups can be informed.

Furthermore, the experimental simulations provided a first glimpse of how a model could aid in understanding dynamics within a system and provide for hypothetic future scenarios of the effectiveness of different kinds of interventions. The current simulations are not based on empirical data or reference modes and include only partially the mental models of the participants. Future research could benefit from the use of more time series data, f.e. from CBS or municipalities, but also educated guesses by experts can provide underpinnings for the diagrams and the scenario's. The participants also acknowledged that more research and data was needed to draw more supported conclusions or test hypotheses.

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Appendices

The following diagrams have been based on- ,and used during, the different group model building sessions. These formed the basis for checking the current dynamic hypothesis with the mental models of the participants.

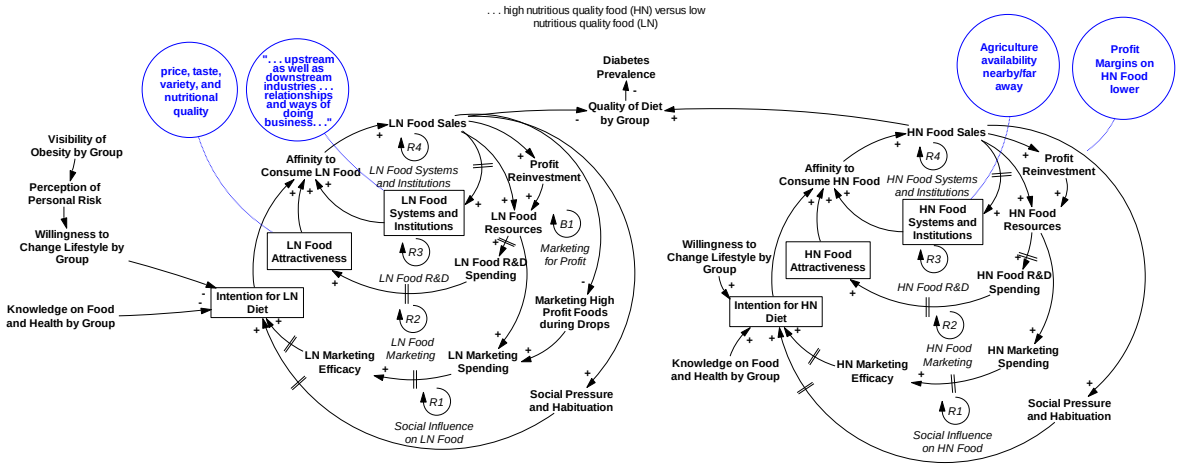

Figure 3. Nutritious quality and the food system (mainly based on Struben et al 2018)

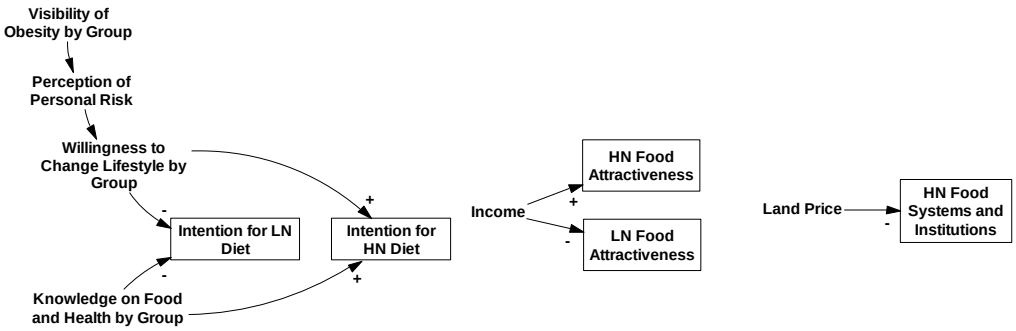

Figure 4. Effects on Food Consumption

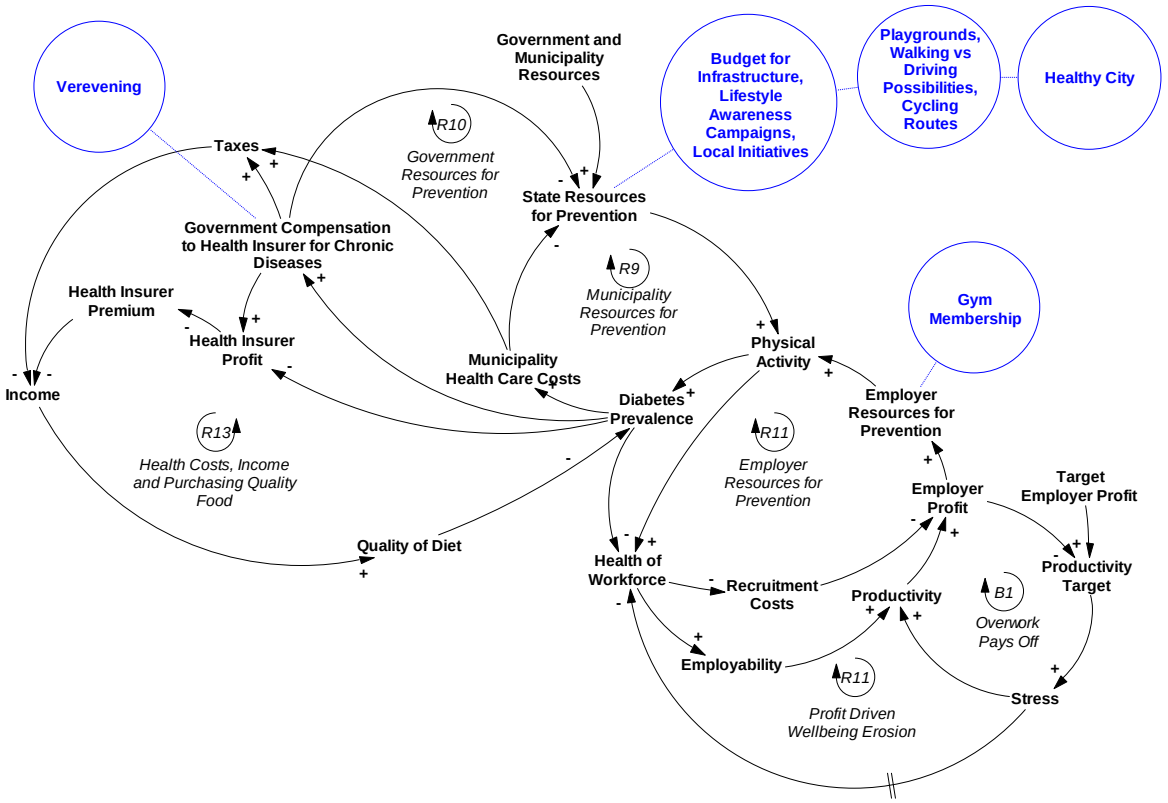

Figure 5. Government, Municipality and Employers

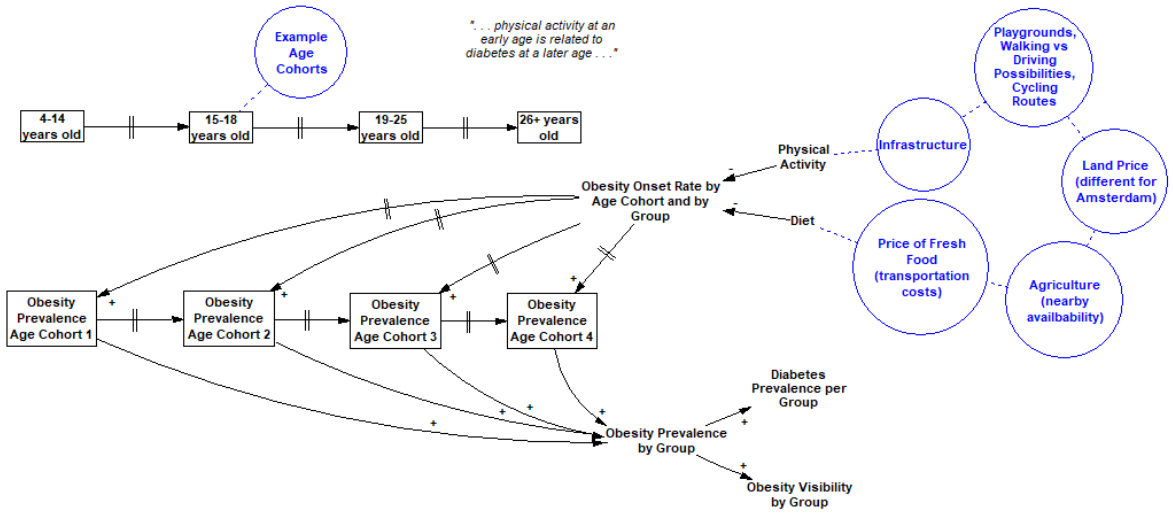

Figure 6. Aging Chain and Obesity Prevalence

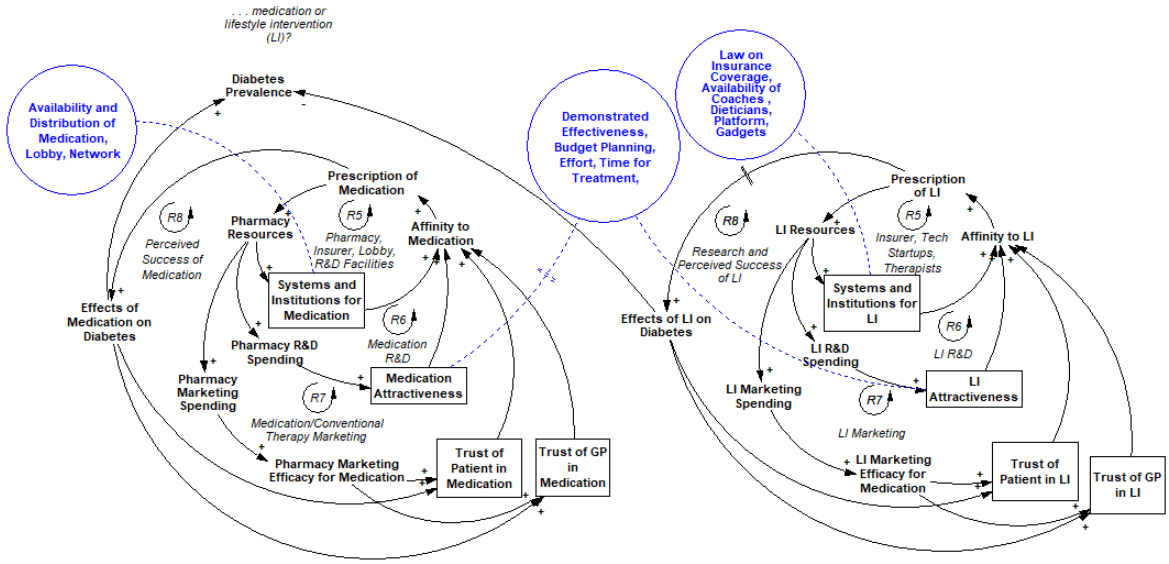

Figure 7. Healthcare provider, Pharmacy, and Insurance