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CO-CREATE

D8.3: International Data File with Document Data – System Dynamics Model

University of Bergen
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Executive Summary

The initial intention behind D8.3 was to share extract from document data in terms of field notes and dialogues from Youth Alliances, with data documentation, openly. However, these document data cannot be shared as it has not been possible to detach the embedded structure of the data, compromising the demand for anonymity of the data.

Data which cannot be anonymised, cannot be shared openly. Instead, we have identified other structured data that can be openly shared. One such outcome of the project is system dynamics (SD) models, as described in D7.1, D7.2 and D7.3. D7.3 gives an in-depth presentation of the main model's structure, use, and limitations. For the benefit of those not familiar with SD models, the project is currently developing a user-friendly interface where data can be manipulated and experimented with without prior knowledge of or experience with SD models.

This document provides an overview of the user-friendly System Dynamics Model and its user-friendly model interface, which WP7 have developed. The model as well as the interface are shared through open access. Additionally, the document provides an overview of the data on which the model and interface are built. Lastly, the document presents the design of the interface and provides information on how users can manipulate data and perform their own experiments with the interface.

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List of acronyms / abbreviations

AdOWOB – Adolescent overweight and obesity

BMI – Body Mass Index

GA – Grant Agreement

HBSC – Health Behaviour in School-aged Children

PA – Physical Activity

PAL - Physical Activity Level

SD – System Dynamics

UoB - University of Bergen

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1.0 Introduction

As defined by the Grant Agreement (GA), Article 29.3, CO-CREATE has committed to share all data openly 'in a research data repository and take measures to make it possible for third parties to access, mine, exploit, reproduce and disseminate – free of charge for any user (…)'.

During the course of the project, it has become clear that not all data are eligible for open access for anonymity reasons. Data which cannot be anonymised cannot be shared openly.

The intention behind this deliverable was to share extracts from document data in terms of field notes and dialogues from Youth Alliances, with data documentation, openly. However, these document data cannot be shared as it has not been possible to detach the embedded structure of the data, compromising the demand for anonymity of the data.

Instead, we have identified other structured data that can be openly shared. One such outcome of the project is system dynamics (SD) models, as described in D7.1, D7.2 and D7.3. D7.3 gives an in-depth presentation of the main model's structure, use, and limitations. For the benefit of those not familiar with SD models, the project is currently developing a user-friendly interface where data can be manipulated and experimented with without prior knowledge of or experience with SD models.

The following document provides a general overview and description of the SD model's interface, which will be shared through open access. The overview is based on D7.1 and D7.3, which should be consulted for a more detailed description.

The project follows the FAIR principles.

The SD model's interface is a work in progress, which is to be completed in June 2023. The presentation of the interface in this document is an early version which may vary from the finished interface. The document will be updated after the interface's completion in June.

2.0 The platform for open access – Sikt

The project has previously shared quantitative data through open access, as described in D8.4. The data shared through open access, as described in this document, will be shared on the same data depository site.

The following description of the platform was published in D8.4:

> The Norwegian Agency for Shared Services in Education and Research (Sikt) was established on January 1st through a merger between Norwegian Center for Research Data AS, Uninett AS, and the Norwegian Directorate for ICT and Joint Services in Higher Education & Research. Sikt is part of the OpenAIRE network as the Norwegian National Open Access Desk.
>
> The project will use Sikt as a platform for archiving and sharing data. Sikt is a free service without time restriction. Meaning the project's data will be available indefinitely.

When sharing data through Sikt, there are several possibilities regarding the accessibility of the data. The data can be shared openly without access control, with registration, or for a limited audience (e.g., researchers, scholars, students).

CO-CREATE has decided to share data openly, with the registration requirement, to keep track of who uses the data. Besides registering an email address, there are no limitations to downloading the data.

3.0 Data overview – System Dynamics (SD) Model

SD modelling allows for an easily accessible approach to explore the short- and long-term impact that youth-generated policy ideas may have on adolescents' overweight and obesity (AdOWOB). The model captures the dynamics of AdOWOB at a population level by integrating the processes of human metabolism, body composition, physical activity environment, food environment, and mental wellbeing. Each process is not independent, and the model captures the complex interdependencies between them in the regulation of body weight and energy dynamics, and the environment. Each process has been divided into a corresponding module/sub-model, as seen in Figure 1.

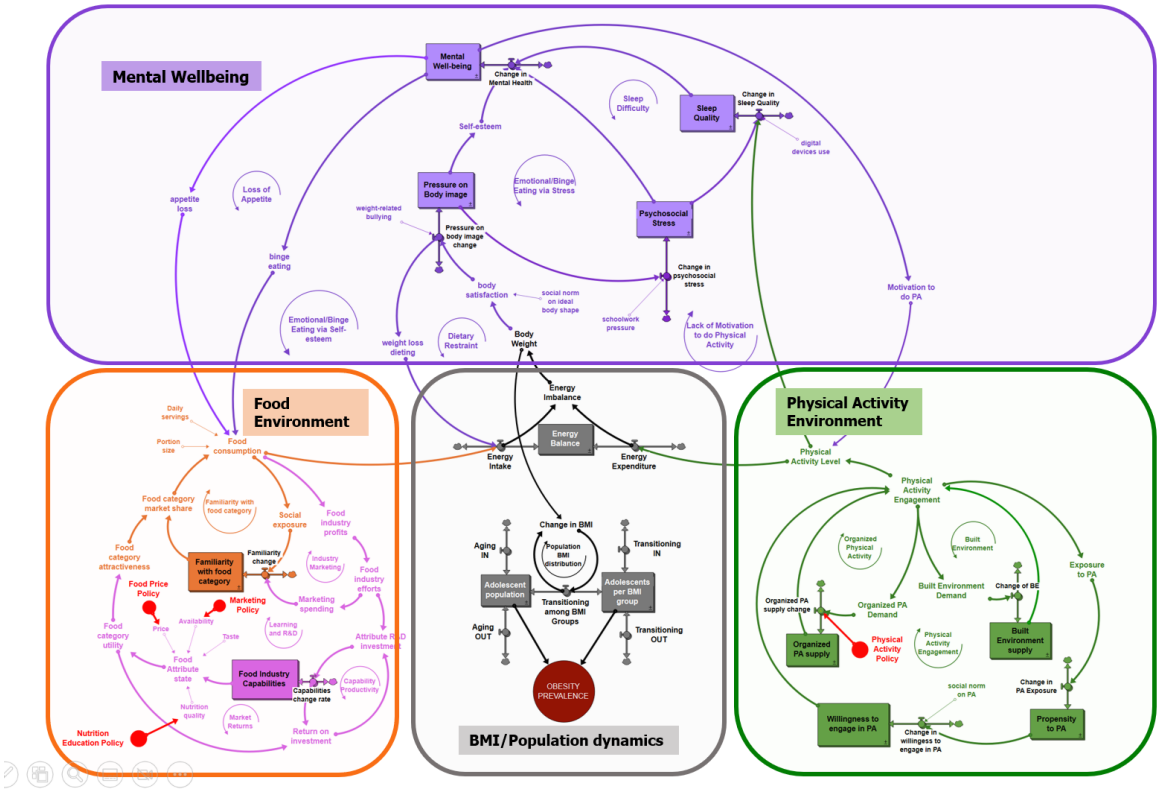

Figure 1. Aggregated model structure [Purple: Mental Wellbeing, Green: Physical Activity Environment, Orange: Food Environment, Grey: BMI/Population Dynamics, Red: Youth-suggested policy ideas] (D7.3, p.11)

The model draws on various sources, including results from the CO-CREATE project. WP7 has structured and combined different results and outcomes from both internal and external sources. In D7.3, WP7 presents the foundation of the model as follows:

> The model is based on D7.1 A systematic review on existing system dynamics models on overweight and obesity in children and adolescents and previous systems approaches to childhood obesity, a master system map drawing on all the system maps made in D4.2 in WP4 (also D4.6 Country and master maps and D4.5 Structures for modelling), a translation of the consensus map into a stock and flow diagram, and quantification of the diagram. Moreover, from the policy briefs generated in Deliverable 5.3 CO-CREATE youth alliances' policy briefs, five policies were selected and incorporated in the model to conduct sensitivity and scenario analyses. The model serves as a knowledge repository in that it integrates previous work packages results and other sources. The model can be used to conduct a series of simulation experiments to understand the major feedback mechanisms driving youth obesity.

The following section will include a brief overview of each of the four modules in the SD model and the foundation on which they are built.

3.1 BMI/Population dynamics

This module aims to map obesity prevalence amongst adolescents in three population groups: 11-, 13-, and 15-year-olds. The adolescents are in each category for two years. Meaning, they move into different age groups when they grow older until they turn 17 years old. The BMI was distributed into three weight categories: normal weight, overweight, and obese. The model relies on data from the Norwegian part of the Health Behaviour in School-aged Children (HBSC) study (www.hbsc.org), which also includes underweight observation. For the purpose of the SD model, underweight was categorised in the same category as normal weight.

A detailed description of the module, including the method and validation of simulation, can be found in D7.3, pp. 12-13.

3.2 Physical activity environment

The Physical Activity module accounts for the various factors that affect an individual's Physical Activity Level (PAL), which in turn influences their energy expenditure. The PA module then uses this information to compute a BMI that represents an individual's characteristics and to determine the prevalence of overweight and obesity across the population.

There are four main stocks in the PA module. Two stocks are divided into organised- and self-organised PA. The organised PA includes, e.g., organised sports activities after school. The self-organised PA depends more on available built environments, such as green spaces, sidewalks, bike paths, sports facilities etc. This represents the supply component of the PA environment, which entails that investments in these two concepts are crucial to increase PA engagement in adolescents.[1]

The last two main stocks are willingness and propensity to engage in PA. The PA supply from after-school activities and the built environment influence both stocks. By capturing the interaction between

[1] See D7.3, Appendix 4, for complete list of variables

the stocks, the module determines the overall proportion of adolescents engaged in PA. This outcome is subsequently linked to the physiological module to derive PAL, which, in turn, determines energy expenditure.

For a more detailed description of the PA module, see D7.3, pp. 13-14.

3.3 Food environment

The food environment module includes and structures commercial food factors. The module is divided into two main sections, demand, and supply. The demand section includes, e.g., the consumer perspective, while the supply sector includes, e.g., the food industry's perspective. Furthermore, food is divided into two food categories: highly nutritional and low nutritional foods.

The main stock in the demand sector is consumers' affinity to one of the two food categories. The main stock in the supply sector relates to the investments or resources the food industry uses to develop specific food capabilities. The accumulation of capabilities related to a specific food attribute relies on a combination of factors, including productivity, overall efforts, and the proportion of resources directed towards enhancing that attribute.

There is a clear link between the consumer's affinity for a food category and the food's capabilities. The food capabilities are thus an investment area for the food industry. The industry aims to increase profit by investing money in marketing, research, and development. By investing money in creating attribute-specific capabilities through learning, research, and development, the industry can directly influence the utility consumers obtains from consuming a specific food category. Meaning, attribute-specific capabilities increase sales, which in turn increases profit, and thus create more money to be reallocated to learning, research, and development.

Within the learning parameter of the food industry, the industry inspects the market for products and attributes which may produce a higher return on investment. More money will be allocated to develop the categories and attributes they presume will produce a higher return on investment.

See D7.3, pp. 14-15, for a more detailed description of the Food Environment module.

3.4 Mental wellbeing

The module for mental wellbeing encompasses the primary mental health processes that contribute to obesity-related behaviours, which in turn result in AdOWOB. The main drivers of the module are three reinforcing loops: emotional/binge eating, lack of motivation to do PA, and sleep difficulty.

For more details, see D7.3 pp. 15-16.

3.4.1 Emotional/Binge eating loop

Body weight → Body image satisfaction → Pressure on body image → Self-esteem → Psychosocial stress → Emotional eating → Consumption of Unhealthy food & drinks → Energy intake → Energy imbalance → Body weight.

The emotional feedback loop begins with weight bias resulting from the difference between the ideal and actual weight of representative adolescents of each gender and age group. This weight bias creates

pressure on body image and dissatisfaction with weight status, leading to reduced mental wellbeing and subsequent obesity (Fismen et al., 2022). The pressure on body image exacerbates psychosocial stress and low self-esteem, both of which are linked to poor mental wellbeing in adolescents. Psychosocial stress is comprised of stressors such as school pressure, weight-related bullying, and perceived pressure on body image. The combination of increased psychosocial stress and poor mental wellbeing results in emotional eating behaviours, which increase caloric intake and contribute to higher body weight, further perpetuating weight bias.

3.4.2 Lack of motivation to do PA loop

Body weight → Body image satisfaction → Pressure on body image → Psychosocial stress → Mental Wellbeing → Motivation to do PA → Physical activity engagement → Physical activity level → Energy expenditure → Energy imbalance → Body weight

The motivation to do PA loop depicts the cycle triggered by adolescents experiencing body dissatisfaction due to a disparity between their current and ideal weight. Similar to the emotional/binge eating loop, weight bias creates pressure on body image, which further intensifies psychosocial stress and reduces motivation for PA. Lower motivation for PA results in reduced engagement and lower PA levels, leading to decreased energy expenditure and an overall positive energy balance, ultimately resulting in higher body weight.

3.4.3 Sleep difficulty loop

Body weight → Body image satisfaction → Pressure on body image → Psychosocial stress → Sleep quality → Mental wellbeing → Emotional eating/Loss of appetite → Consumption of unhealthy food & drinks → Energy intake → Body weight

As the perceived pressure on body image increases, psychosocial stress increases as well, which reduces sleep quality. The lower the quality of sleep, the lower the mental wellbeing. Poor mental wellbeing leads to unhealthy eating behaviours, either stress eating or loss of appetite, which intensifies body image dissatisfaction and increases pressure on body image further.

4.0 Design of Interactive SD Model

4.1 Interactive SD model – aims and limitations

Figure 2. Frontpage of SD model interface

The SD model interface has five distinct aims:

1. To serve as an environment for understanding the underlying feedback mechanisms governing youth obesity.
2. To conduct simulation experiments where the short- and long-term impact of youth-generated policy ideas are explored.
3. To focus on insights that tell feedback stories that can be used to inform policy designs.
4. To explore leverage points for obesity prevention.
5. To support broad discussion among key stakeholders and policymakers.

There are, however, some limitations to the model and the interface:

1. This SD model is not intended to be used as a decision-making tool, for example, to support the analysis of competing policies.
2. Heterogeneity is not captured in this SD model as the level of aggregation is high.
3. There are some difficulties calibrating highly aggregated variables, such as high/low nutritious food and the built environment.
4. There are some quantification challenges of intangible variables, particularly the ones related to mental wellbeing.

The interface is structured with a menu on the left where the user can shift between different categories and tabs, which include sub-categories within each category. Figure 3 shows an example of the interface, where the users can see an overview of the model.

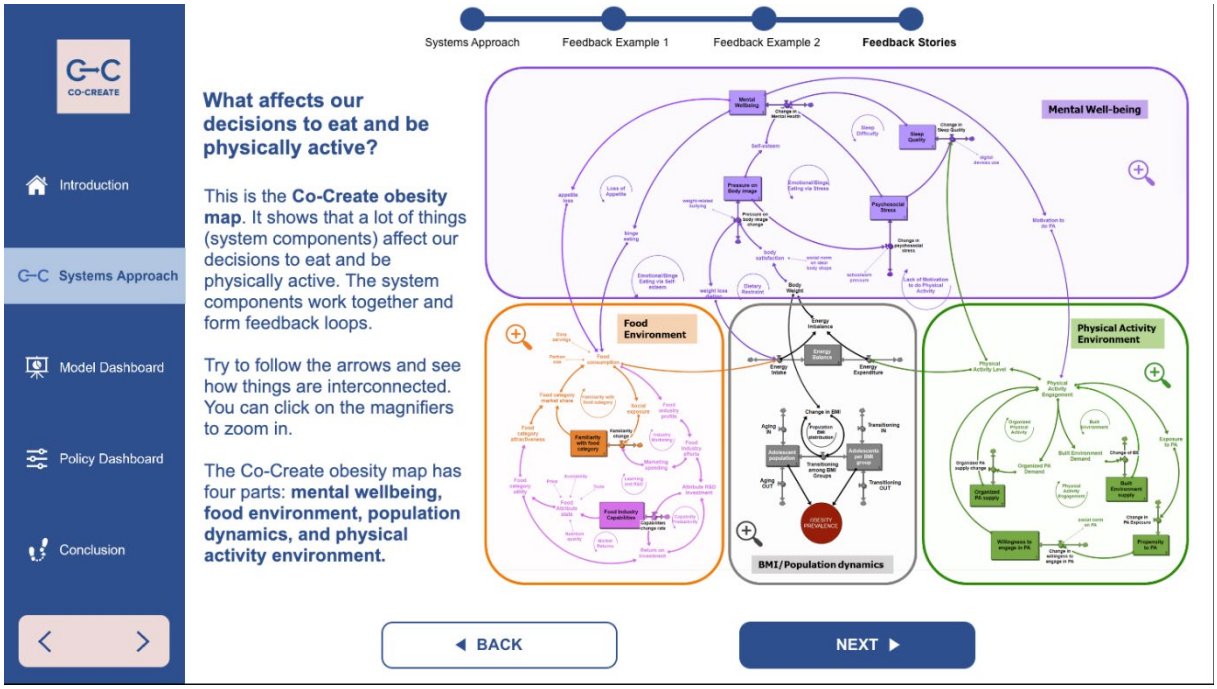

Figure 3. SD model - Model details for food environment

The following section is structured according to the main categories. Each category will be presented in turn.

4.2 Model Dashboard

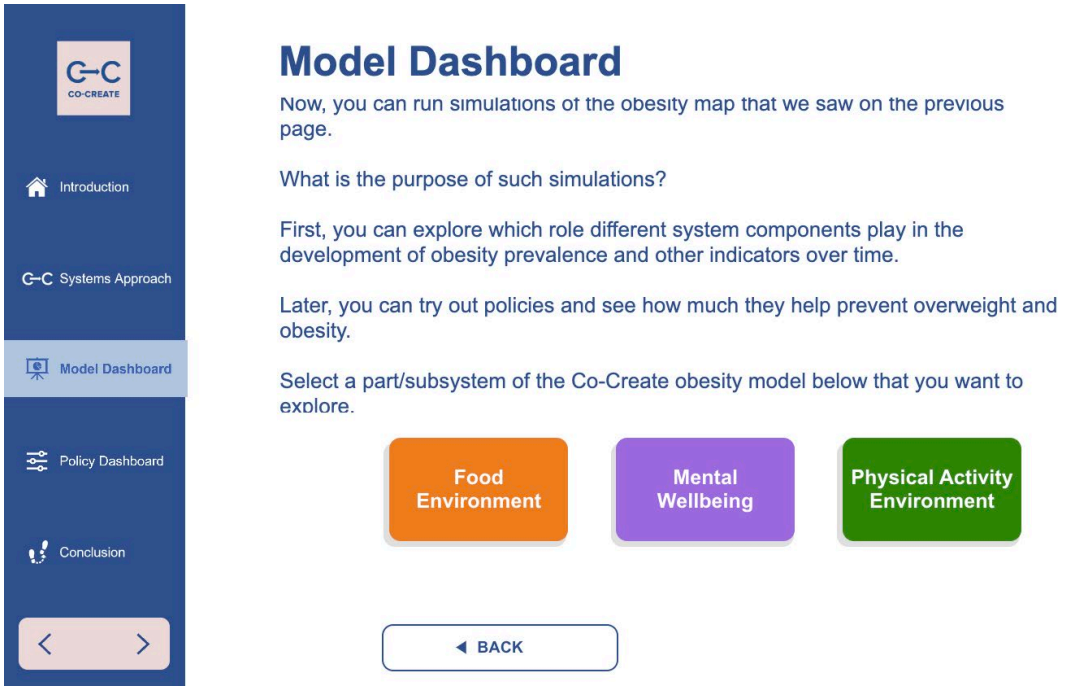

Figure 4. Overview of Model Dashboard

The model dashboard category allows users to manipulate data from each of the three modules tied to AdOWOB, as presented in section 3. Each category corresponds to a clickable button, as seen in Figure 4.

4.2.1 Food environment

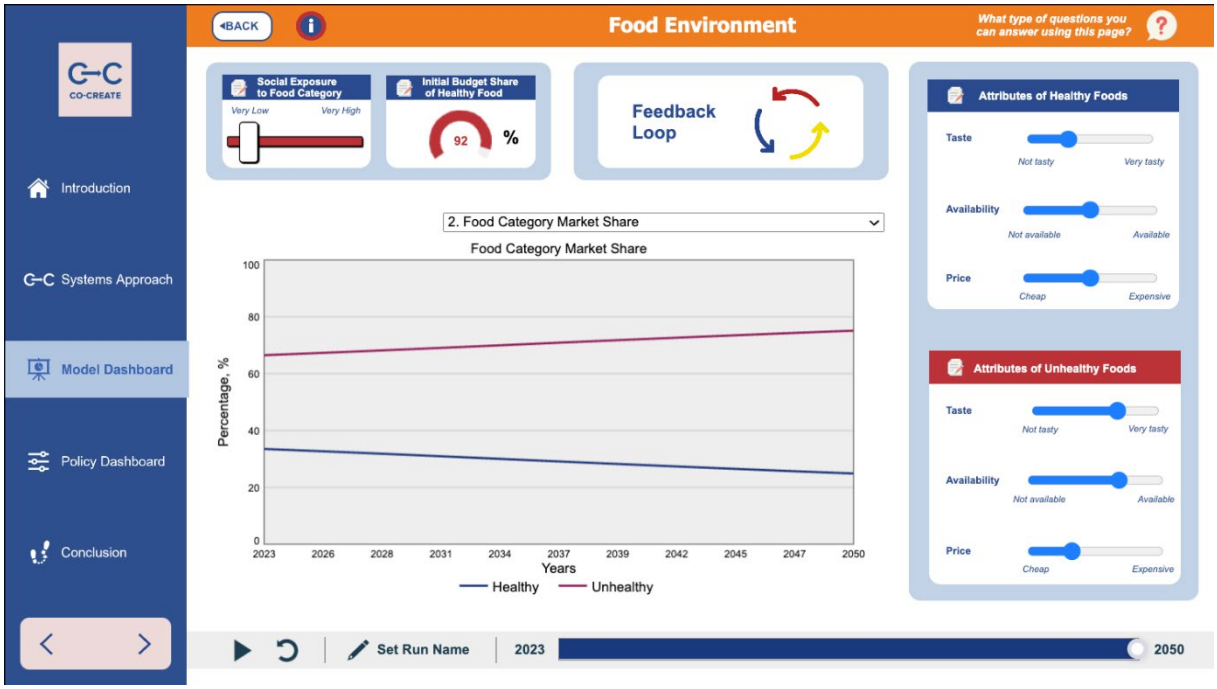

Figure 5. Model Dashboard - Food environment

The Food Environment category allows users to manipulate the food attributes for both high and low-nutritious food. Additionally, the users can change the effect of social norms through the social exposure function and change the percentage of investment in high- vs low-nutritious food.

The user is given the option to view three different outcomes in this category:

1. Food Category Market Share (as seen in figure 5.)
2. Kcal consumption per day
3. Prevalence of AdOWOB.

4.2.2 Mental wellbeing

Figure 6. Model Dashboard - Mental Wellbeing

The Mental wellbeing module allows users to manipulate data tied to the primary mental health processes contributing to obesity-related behaviour and the reinforcing loops, as presented in section 3. The user can change the effect social norms have on mental wellbeing and the ideal body weight. The user can also add policy effects on bullying and computer overuse.

The users are given the option to view four different outcomes in this category:

1. Mental wellbeing (as seen in Figure 6)
2. Psychosocial stress age 13
3. Pressure on body image age 13
4. Prevalence of AdOWOB

4.2.3 Physical Activity Dashboard

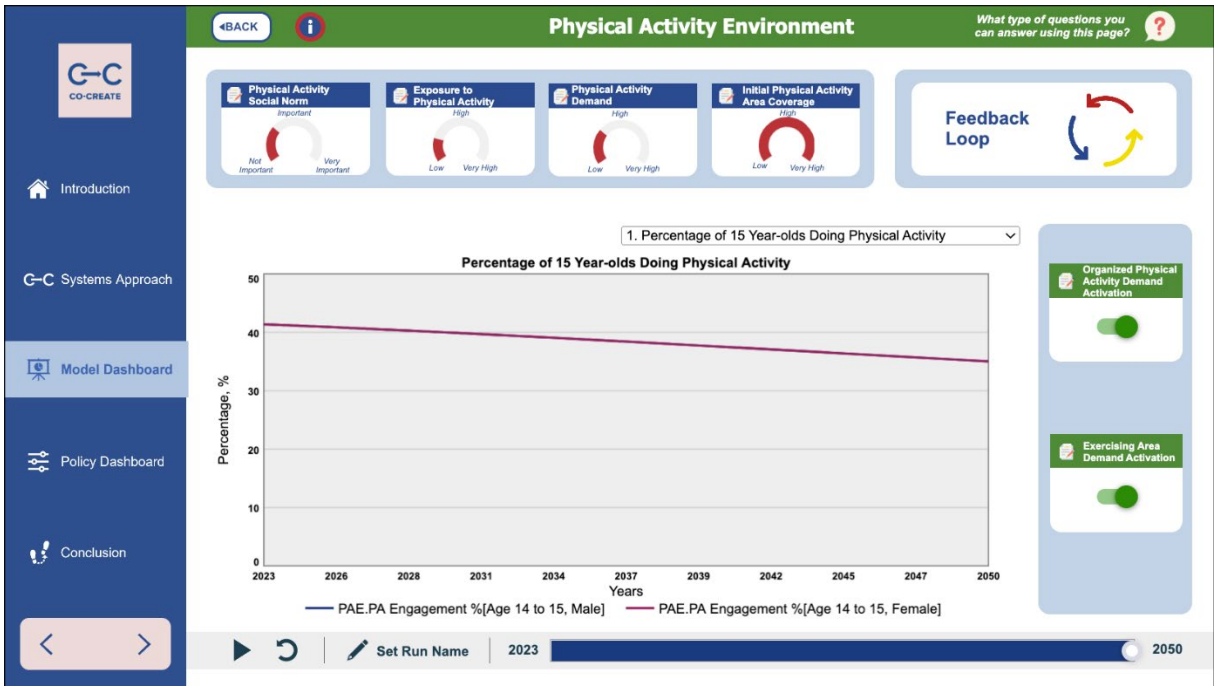

Figure 7. Model Dashboard - Physical Activity Environment

The PA Environment dashboard allows users to manipulate data on PA. The user can manipulate four different variables, in addition to being given the option to omit organised PA and/or built environment from the simulation and add a 'no policy' option.

The first variable which can be manipulated is the weight of social norms. This variable indicates how social norms determine the fraction of adolescents' participation in PA. The second variable, the weight of exposure, calculates the percentage of adolescents in the first age group being given a PA engagement. The third, Fraction for Demand Built Environment, allows users to change the percentage of adolescents to use the built environment under normal conditions. The last variable, Fraction for Built Environment INIT, is the initial value of the built environment stock.

There are four possible outcomes in the PA environment category:

1. Percentage of 15-year olds doing physical activity (as seen in Figure 7)
2. Usage of exercise area
3. Supply and demand of exercise area
4. Prevalence of AdOWOB

4.3 Policy Dashboard

The policy dashboard category allows users to experiment with scenarios related to policy duration and policy magnitude. There are five areas in which the users can experiment:

1. Increase unhealthy food price
2. Restrict unhealthy food marketing
3. Reduce portion size
4. Access to physical activity
5. Nutrition education

The policy dashboard is divided into two sections, as seen in figure 8. The Policy Duration section is located above the graph, while the Policy Strength section is located to the right.

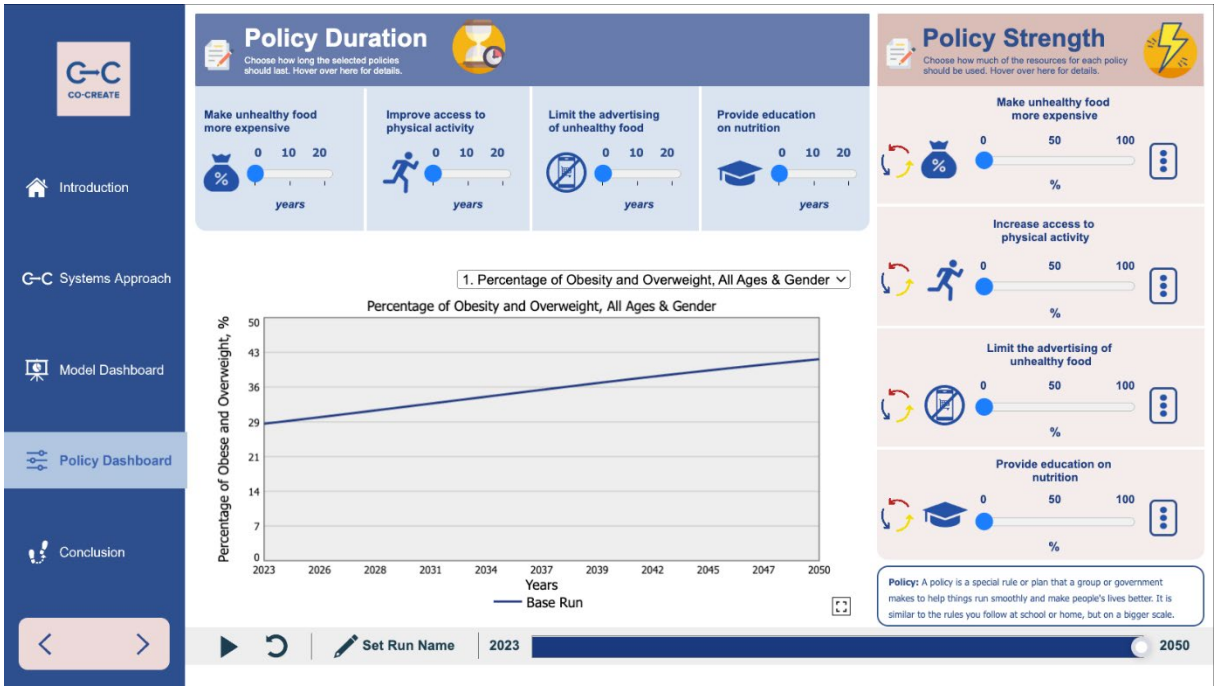

Figure 8. Policy Dashboard

The policy duration function allows users to manipulate different policy areas and decide how long each area should last, from 0 to 20 years. By experimenting with duration, the users can answer questions such as 'How long should policy x last or receive support to impact obesity prevalence?'

The policy strenght function is an aggregated concept that includes both allocated resources and policymakers' commitment. By experimenting with the data, users can answer questions such as 'How strong should policy x be to impact obesity prevalence?'.

Conclusion

The user-friendly SD model interface opens the door for a variety of different uses. Most prominent is perhaps the possibility of promoting the model as a tool for teaching and learning. By engaging teachers, schools, and communities with experiments on data related to AdOWOB, the model can allow for better understanding of complex problems from a systems perspective as well as potentially raise awareness for both adolescents and adults alike - which in turn may act as an instigator for change.

Additional Information

1. The computer model, data file required to run the model and full model documentation are available for download from https://github.com/bkopains/Co-Create-CoDyMAdOb-model. A publication based on this model is published here https://onlinelibrary.wiley.com/doi/10.1111/obr.13628.
2. The user-friendly interactive learning environment is freely available on the isee exchange server: https://exchange.iseesystems.com/public/birgit/co-create-simulation-tool-of-adolescent-obesity/index.html#page1

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D7.2 *Articles of simulation of policy effects* (p. 50).

D7.3 *A system dynamic model (knowledge repository)* (p. 173).

D8.4 *Open access survey data file with documentation* (p. 14).

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