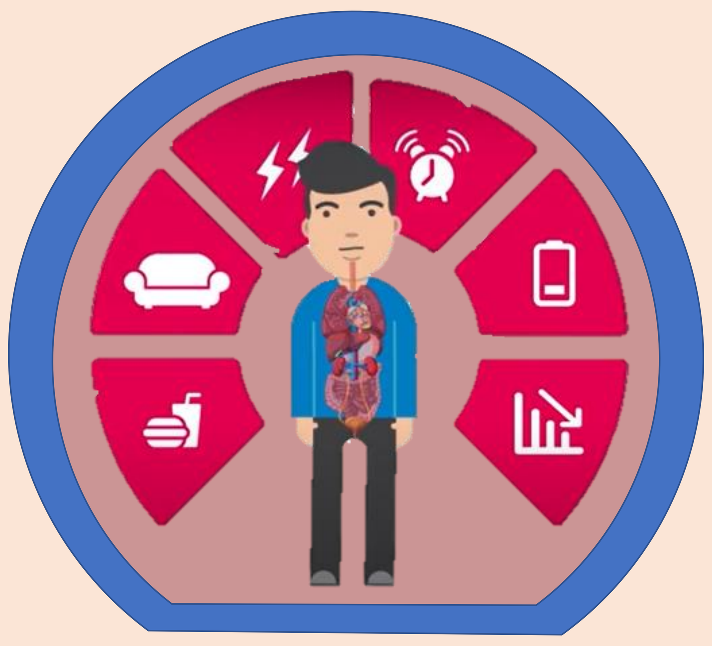

Understanding Type 2 diabetes population dynamics in The Netherlands through simulation modelling of effectiveness of lifestyle programs

Teun Sluijs[1*], Lotte Lokkers[2], Serdar Ozsezen[1], Heleen M. Wortelboer[1]

[1]*TNO, The Netherlands*, [2]*Radboud University, The Netherlands*

*Contact: teun.sluijs@tno.nl +31 6 43531343

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INTRODUCTION

> The number of individuals suffering from Type 2 Diabetes Mellitus (T2DM) is dramatically increasing worldwide, resulting in an increasing burden on society and rising health care costs.

> T2DM patients can be **reversed** by means of lifestyle changing programs, indicating that shifting from treatment alone to combined lifestyle intervention and prevention program may achieve co-benefits for society, healthcare and individuals [1,2].

> To **explore** the **actual effectiveness of policy interventions**, three interconnected elements (the development of type 2 diabetes, lifestyle programs focused on reversing T2DM and associated societal cost) need to be combined to provide a holistic view on the likely development of interventions on the T2DM population and subsequent cost over time; this is to be seen as a 'wicked problem'.

> A well-suited method for addressing wicked problems is **System Dynamics (SD)**.

SD is deployed to compare realistic policies, incorporating feedback effects, nonlinear relationships, and time delays between variables.

AIM

> The present study aims to develop a SD tool to gain a clear understanding of the T2DM patient journey and the total societal costs associated with developing and treatment of T2DM.

METHOD

> **System Dynamics** is used to simulate complex behavior over time and works with multidisciplinary interrelationships, which are represented in multiple integrated differential equations[3]. The method makes use of stocks and flows. The interaction and feedback between multiple endogenous variables, stocks and flows create the dynamics over time. A standardized iterative process in the SD practice was used (Figure 1).

1. **Get systems understanding**
2. **Define the problem**
3. **Conceptualize the model**
4. **Formulate the model**
5. **Simulate the model**
6. **Perform policy analysis**

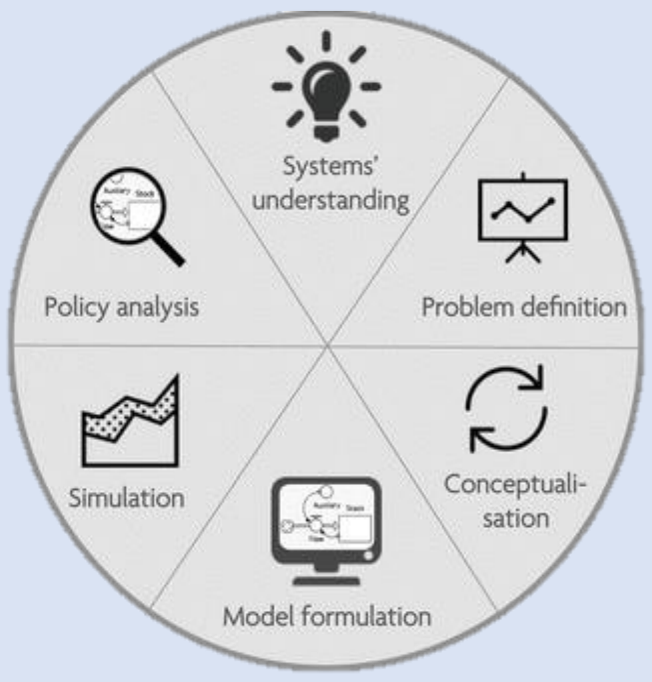

Figure 1: a standard System Dynamics process to capture a dynamic and non-linear problem. Adapted from Sterman (2000).

Step 1, 2, and 3:

- Literature review to find the variables/determinants of T2DM
- The SD model[4] describing the 'patient journey' was 1) adapted to the Dutch environment (module 1 or **M1**), 2) connected to T2DM population and 'intervention program effectiveness' (module 2 or **M2**), and 3) subsequent 'societal/governmental costs' (module 3 or **M3**).

Step 4 and 5:

- Expert interviews were held to elicit their knowledge on T2DM and lifestyle intervention programs and to validate the relationships presented in the preliminary model[5].

Step 6:

- For parameterizing the model, data were extracted from literature and Dutch databases of (among others) CBS, KPMG, Nederlandse Zorgautoriteit, NIVEL, RIVM, and TNO.
- Scenario's were created and were integrated in a preliminary interface to showcase the possibilities of the simulation methodology.

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RESULTS

> For T2DM (**M1**), the following core structure has been created in SD language:

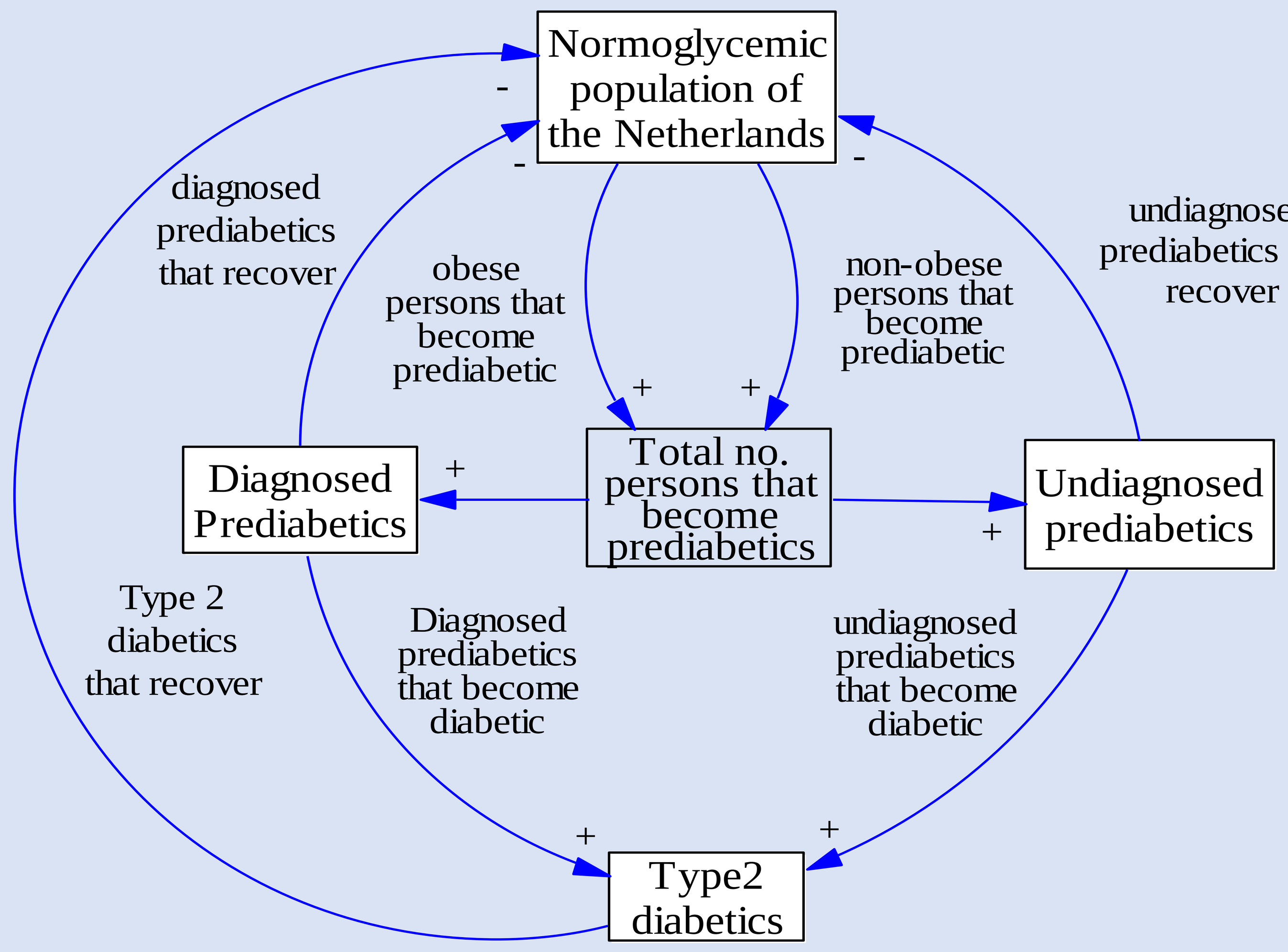


Figure 2: The core structure of the T2DM Patient Journey model through the method of System Dynamics.

(1) A % of population becomes obese, a % thereof becomes pre-diabetic.

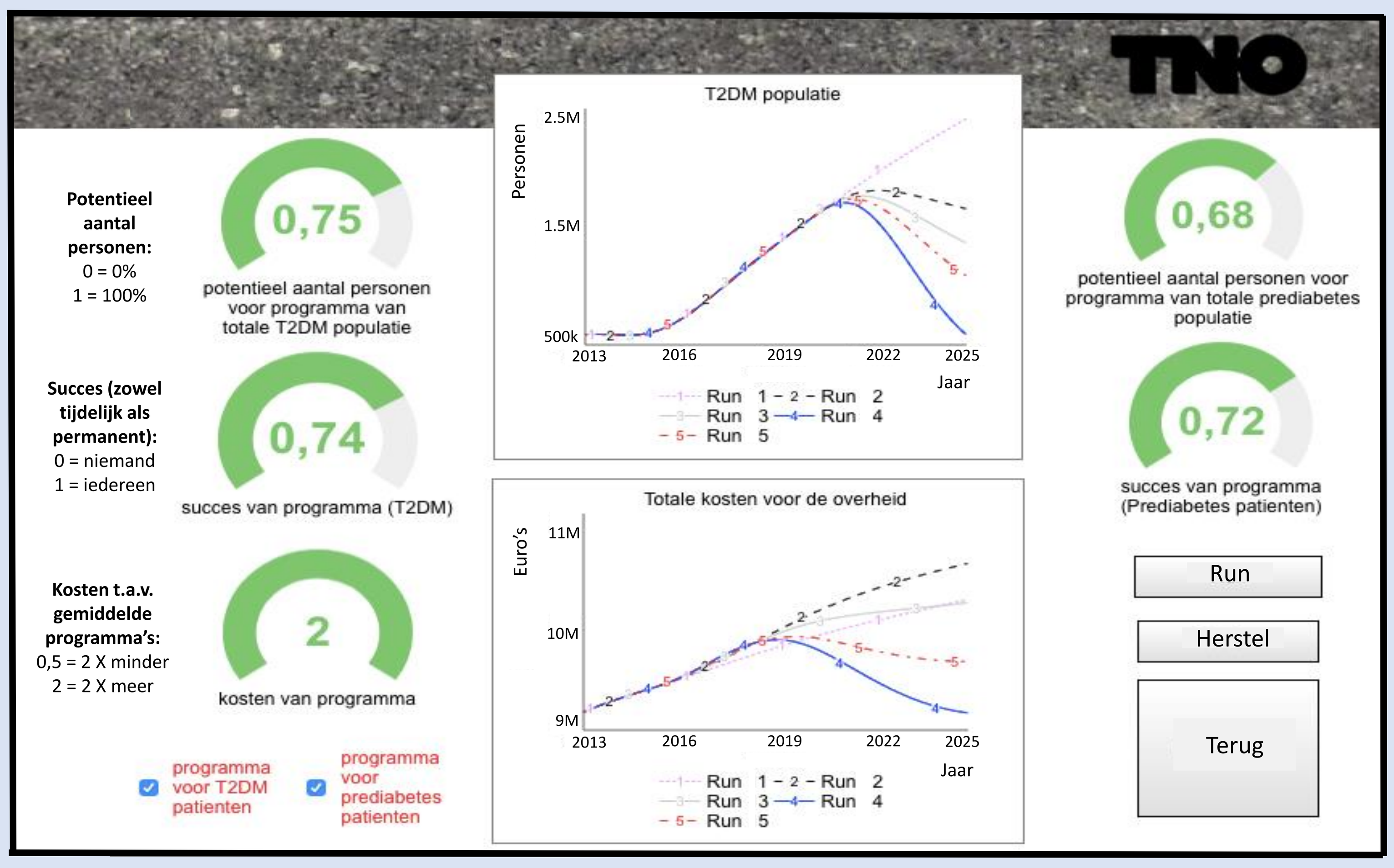
(2) Either the person gets diagnosed or does not, represented as the stocks 'diagnosed' and 'undiagnosed'. A small fraction reverts and are recruited back to the Normoglycemic population through 'recovery'.

(3) However, a large part of these groups becomes a Type 2 diabetic, flowing into the stock 'Type 2 diabetics'.

(4) One can revert from the 'Type 2 diabetics' stock by use of intervention programs.

> Simulations can be made on exploration of the Patient Journey (**M1**) itself, trade-offs between effectiveness in relation to program cost (**M2**), focus on either the T2DM population or prediabetic population, and the amount of patients treated.

> In the policy scenario runs that are represented in Figure 3 which is an output of the model behavior, the following policies are explored, resulting in future T2DM population projections and total cost for the government (**M3**):



Run 1 – Current policy

Run 2 - Highly successful, focusing onT2DM, average cost, selected patients

Run 3 - Averagely successful, focusing on T2DM and Prediabetes, average price, almost all patients

Run 4 - Highly successful, focusing on T2DM and Prediabetes, high price, almost all patients

Run 5 - Averagely successful, focusing on T2DM, low cost, all T2DM patients

Figure 3: Preliminary interface of T2DM Patient Journey model, with scenario runs

CONCLUSIONS

(1) To find the best possible trade-offs in integrated lifestyle programs, intervention strategies on Type 2 diabetes have been explored under various scenarios. On all preventive scenarios of lifestyle change, the governmental cost declines.

(2) The run covering both T2DM and Prediabetes, although costly, reduces the T2DM population the most and subsequently, the cost for government in the long run.

(3) The method of System Dynamics could be successfully applied to understand and simulate complex problems prior to implementing the intervention such as lifestyle interventions on Type 2 Diabetes.