Structure for Type 2 Diabetes Module
Health Finance Institute

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Abstract

This document summarizes the current state of the diabetes module developed by the health economics team at HFI. The module is based on a comportamental model which is used to simulate and evaluate the health and economic effects of different interventions to reduce the burden of diabetes. We consider a set of 3 interventions: prevention, disease management and disease severity. The model is displayed on a user-friendly R-shiny app, where users are allowed to choose the coverage rates for each intervention.

1 The module

The development finance market suffers a crucial failure: the social benefits of investments are, most often, lower to its private returns. Public economics literature names this situation as a market failure since the resulting investments are lower than the social optimum. When such situations occur there is room for intervention, which may be private, public or a mix of both. In any case, this is the main challenge of development finance.

In a broad sense, development finance is broadly defined as leveraging sources of finance, expertise and solutions to support economic development and quality of life in developing countries. It means channeling financing and strategic advisory to promote economic development in emerging markets, as outlined by the United Nations Sustainable Development Goals (SDGs) and the Human Development Index.

Financing development therefore requires a blended finance approach, which when successful is characterized by an incentive environment that foster cooperation. HFI's health economics team intends to provide tools to identify and facilitate the different investment opportunities by providing reliable social and financial impact measures for decision-making. This task is accomplished by using impact evaluation analysis. Shortly defined, impact evaluation is a methodology which intends to assess the effect of a given intervention by comparing a control and treated group before and after a given intervention.

The objective of this document is to provide HFI's methodological approach to analyze the ex-ante impact of financial transactions on development with an example applied to diabetes type 2. This methodology is being developed in collaboration with leading international academic centers and experts in the field. It will be reviewed on a periodic basis to reflect updated industry best practice as required.

This article contains the preliminary draft of HFI's type 2 diabetes module. The module is based on a comportamental epidemiological continuous model. This means that the model describes "states of the world" for a given population, which is usually aggregated in terms of age and gender.
Table 2 describes the rates and proportions included in Figure 1, while Table 3 describes the shares and proportions included. As discussed before, the model reflects the potential health and economic consequences of different interventions. Table 1 summarizes these user-defined parameters. And lastly, table 5 describes the economic parameters that represent a per capita daily expenditure (or saving) measure of the interventions and selected economic outcomes.

1.1 Dynamics and assumptions

The model simulates the health trajectories of different sub-populations based on age and gender cohorts. We divide age cohorts based on 6 different cohorts: children between 0 and 10 years old; adolescents between 10 and 19 years old; adults between 20 and 30, 40 and 50, 50 and 60 years old, and older than 60. This means that we have 12 different sub-populations.

Figure 1 presents a view of the stock-and-flow structure used in modeling Type 2 diabetes. The model starts by defining a population at risk for developing diabetes primarily by virtue of being overweight and physically inactive, or having a family history of diabetes. In a second stage, a fraction of the population at risk receives an intervention to screen for diabetes. Following the American Diabetes Association, testing should be repeated for suspicious patients (e.g. those with a A1C levels between 5.7-6.4) on a subsequent day to confirm the diagnosis.

Two different interventions are available for the subset of patients who were classified as non-diabetic or pre-diabetic: one fraction in each group receives a risk factor reduction intervention (e.g. diet and physical activity), while the other fraction only gets access to a regular screening routine. Key assumptions for the model is that people cannot move from diabetes to non-diabetes; this assumption is reasonable because remission is extremely rare (Boyle et al, 2010).

Three potential states are available for patients who were detected with diabetes, either in Phase 1, 2 or 3: a) High cost treatment; b) Low cost treatment; and c) to remain untreated (the uncontrolled state). Aside of the price, the main difference between the high and low cost treatment is that the former has a higher rate of success to stop disease progression when patients adhere to it. On the contrary, when patients receive the low cost treatment, the probability that the patient will experience disease progression (either from diabetes phase 1 to phase 2, or phase 2 to complications) is bigger than zero.

Afterwards, a subset of patients who receives the treatment in phase 2 get monitored for potential complications (e.g. cardiovascular disease, diabetic retinopathy, diabetic neuropathy or diabetic nephropathy.). The rest and the patients who are uncontrolled develop complications and do not get monitored.

As mentioned previously, there is a fraction of patients that remain undiagnosed. To simplify the model, it is assumed that undiagnosed patients with pre-diabetes or diabetes will eventually experience a decay in health due to higher sugar levels. Since these patients remain undiagnosed they advance toward the undiagnosed phase 2/3 which eventually leads to experience all the complications related to diabetes. An exception is applied to undiagnosed patients whose real status is non-diabetic. For such patients, a fraction goes to undiagnosed pre-diabetic and the remaining have the chance to be screened in a further period.

1.2 Parameters

The following tables in this section summarize the parameters the model uses and that should be appropriately calibrated. Table 1 show the user-defined parameters for the considered interventions. Table 2 shows the rates at which patients transition from one state to other, while table 3 contains the proportion parameters. Table 4 show the initial values for the simulation. Table 5 show the economic parameters.

Table 1: Intervention parameters

Rate	**Description**	Value
i_{test}	Screening rate	User defined
i_{retest}	Retesting rate	(set to one)
i_{RFR}	Risk Factor reduction	User defined
$i_{treatment}$	Percentage of treated patients	User defined
i_{hct}	Percentage of treated patients under high cost treatment	User defined
$i_{lct} = (1 - i_{hct})$	Percentage of treated patients under low cost treatment	User defined
i_{monit}	Percentage of patients with access to monitoring	User defined

2 Empirical strategy to estimate parameters

2.1 About the data sources

The health outcomes and the direct costs parameters are mainly derived from the Mexican Survey of Health and Nutrition survey (ENSANUT).

ENSANUT has 5 cross-sectional waves (i.e. 2000, 2006, 2012, 2016 and 2018). It consists on questions that captures health status and nutrition of Mexicans. This is done by retrieving information related to health and diet, such as food and beverage consumption, understanding of food labeling, long-term illnesses, physical activity, vaccination, health services and social programs of food aid, among others.

Table 2: Rates description and model calibration.

Rate	**Description**	Value
R_{D1HC}	Rate at which individuals in phase 1 are given the HC treatment	1
R_{D1LC}	Rate at which individuals in phase 1 are given the LC treatment	1
R_{D1LC_D2LC}	Rate at which individuals in phase 1 are given the LC treatment	0.1
R_{D1U}	Rate at which individuals in phase 1 become uncontrolled	0.2
R_{D1U_D2U}	Rate at which individuals in uncontrolled phase 1 state switch to uncontrolled phase 2 state	0.2
R_{D2HC}	Rate at which individuals in phase 2 are given the HC treatment	1
R_{D2LC}	Rate at which individuals in phase 2 are given the LC treatment	1
R_{D2U}	Rate at which individuals in phase 2 become uncontrolled	0.1
R_{D2LC_M}	Rate at which individuals in phase 2 under the LC switch to the monitored state	0.1
R_{D2U_M}	Rate at which individuals in uncontrolled phase 2 state get monitored	0.1
R_{UND_A}	Rate at which individuals in the undiagnosed non-diabetic state remain non-diabetic at risk	0.1
R_{UND_ANRFR}	Rate at which individuals in the undiagnosed non-diabetic state remain non-diabetic at risk w/o RFR	1
R_{UND_UD}	Rate at which individuals in the undiagnosed non-diabetic state become diabetic	0.03
R_{M_CVD}	Rate at which patients monitored develop CVD	0.03
R_{M_DNEPH}	Rate at which patients monitored develop DNEPH	0.03
R_{M_DNEUR}	Rate at which patients monitored develop DNEUR	0.03
R_{M_DR}	Rate at which patients monitored develop DR	0.03
R_{D2U_CVD}	Rate at which unmonitored patient develop CVD	0.075
R_{D2U_DNEPH}	Rate at which unmonitored patient develop DNEPH	0.075
R_{D2U_DNEUR}	Rate at which unmonitored patient develop DNEUR	0.075
R_{D2U_DR}	Rate at which unmonitored patient develop DR	0.075
R_{UD_M}	Rate at which unmonitored patients get monitored	0.1
R_{UD_CVD}	Rate at which undiagnosed diabetic patients develop CVD	0.1
R_{UD_DNEPH}	Rate at which undiagnosed diabetic patients develop DNEPH	0.1
R_{UD_DNEUR}	Rate at which undiagnosed diabetic patients develop DNEUR	0.1
R_{UD_DR}	Rate at which undiagnosed diabetic patients develop DR	0.1
μ	Natural death rate	0.008
μ_1_CVD	Mortality rate cardiovascular disease	0.05
$\mu_{1,DNEPH}$	Mortality rate diabetic nephropaty	0.05
$\mu_{1,DNEUR}$	Mortality rate diabetic neuropaty	0.05
$\mu_{1,DR}$	Mortality rate diabetic retinopathy	0.05
$\mu_{2,CVD}$	Mortality rate cardiovascular disease non-monitored	0.15
$\mu_{2,DNEPH}$	Mortality rate diabetic nephropaty non-monitored	0.15
$\mu_{2,DNEUR}$	Mortality rate diabetic neuropaty non-monitored	0.15
$\mu_{2,DR}$	Mortality rate diabetic retinopathy non-monitored	0.15

Table 3: Rates description and model calibration.

Rate	Description	Value
S_{A_SUS}	Share of suspicious individuals	0.6
S_{A_ND}	Share of A ND individuals	0.3
S_{A_UND}	Share of undiagnosed individuals with no-diabetes	0.009
S_{A_UD}	Share of undiagnosed individuals with diabetes phase 2	0.001
S_{ND}	Share of suspicious individuals with ND	0.1
S_{PD}	Share of suspicious individuals with PD	0.8
S_{D1}	Share of suspicious individuals under phase 1	0.05
S_{D2}	Share of suspicious individuals under phase 2	0.05
S_{ANRFR_SUS}	Share of suspicious individuals	0.35
S_{ANRFR_ND}	Share of ANFR individuals with ND	0.3
S_{ANRFR_UND}	Share of ANRFR with undiagnosed individuals with no-diabetes	0.3
S_{ANRFR_UD}	Share of ANRFR undiagnosed individuals with diabetes	0.05
S_{D1LC_D2LC}	Share of D1 patients under LC who develop D2 and get LC treatment	0.4
S_{D1U_D2U}	Share of uncontrolled D1 patients who develop D2	1
S_{D2U}	Share of individuals in phase 2 become uncontrolled	0.4
S_{D2HC}	Share of individuals in phase 2 are given the HC treatment	0.2
S_{D2LC}	Share of individuals in phase 2 are given the LC treatment	0.4
S_{ND_A}	Share of individuals ND that get RFR	0.5
S_{PD_A}	Share of individuals PD that get RFR	0.5
S_{ND_ANRFR}	Share of individuals ND without RFR	0.5
S_{PD_ANRFR}	Share of individuals PD without RFR	0.5
S_{M_CVD}	Share of patients monitored develop CVD	0.25
S_{M_DNEPH}	Share of patients monitored develop DNEPH	0.25
S_{M_DNEUR}	Share of patients monitored develop DNEUR	0.25
S_{M_DR}	Share of patients monitored develop DR	0.25
S_{UD_CVD}	Share of patients monitored develop CVD	0.25
S_{UD_DNEPH}	Share of patients monitored develop DNEPH	0.25
S_{UD_DNEUR}	Share of patients monitored develop DNEUR	0.25
S_{UD_DR}	Share of patients monitored develop DR	0.25
S_{UND_A}	Share of individuals in the undiagnosed non-diabetic state remain at risk non-diabetic	0.45
S_{UND_ANRFR}	Share of individuals in the undiagnosed non-diabetic state remain at risk non-diabetic ANRFR	0.45
S_{UND_UD}	Share of individuals in the undiagnosed non-diabetic state become pre-diabetic	0.1

Table 4: Economic parameters expressed in daily dollars per capita.

Rate	**Description**	Value
A	Population at Risk who recieves RFR	0
ANRFR	Population at Risk who does not recieve RFR	0
SUS	Suspicious population	0
ND	Non-Diabetic	4000000
PD	Pre-diabetic	2500000
D1	Diabetes phase 1	750000
D2	Diabeses phase 2	250000
UND	Undiganosed non-diabetic	1000000
UD	Undiagnosed diabetic	1500000
D1HC	Diabetic phase 1 patients under HCT	0
D1LC	Diabetic phase 1 patients under LCT	0
D1U	Uncontrolled diabetic phase 1	0
D2HC	Diabetic phase 2 patients under HCT	0
D2LC	Diabetic phase 2 patients under LCT	0
D2U	Uncontrolled diabetic phase 2	0
M	Monitored patients	0
M_CVD	Monitored patients with CVD	0
M_DNEPH	Monitored patients with DNPEH	0
M_DNEUR	Monitored patients with DNEUR	0
M_DR	Monitored patients with DNEUR	0
UD_CVD	Undiagnosed patients with CVD	0
UD_DNEPH	Undiagnosed patients with DNPEH	0
UD_DNEUR	Undiagnosed patients with DNEUR	0
UD_DR	Undiagnosed patients with DNEUR	0

Table 5: Economic parameters expressed in daily dollars per capita.

Rate	**Description**	Value
p_{screen}	Per capita daily expenditures in screening	2.7
p_{rfr}	Per capita daily expenditures in RFR	2.7
p_{hct}	Per capita daily expenditures in HCT	5.4
p_{lct}	Per capita daily expenditures in LCT	1.8
p_{monit}	Per capita daily expenditures in monitoring	4.11
p_{mcomp}	Per capita daily expenditures in monitoring patients w/comp	6.8
p_{yll}	Per capita daily savings in YLL	4.1
p_{yll_pd}	Per capita daily savings in YLL for Prediabetics	2.1
p_{abs}	Per capita daily savings for absenteeism	0.8
p_{prs}	Per capita daily savings for presenteeism	0.5

In addition, ENSANUT includes anthropometrics (i.e. weight, waist and height) and a finger blood sample to determine anemia. In some adults, blood pressure and a venous blood sample will be taken to determine chronic diseases, such as diabetes mellitus or high cholesterol.

The survey describes health status of men and women under 5 years, children from 5 to 11, adolescents from 11 to 19 and adults 20 years and older.

For the set of parameters that are not possible to estimate based on ENSANUT, we use the Mexican Health and Ageing Survey (MHAS) and The Mexican Family Life Survey Survey (MxFLS). Both are longitudinal surveys which allow to capture health trajectories in the targeted population.

2.2 Health outcomes parameters.

The epidemiological model requires three set of parameters:

- Prevalence rates (e.g. proportion of individuals with type 2 diabetes).
- Rates of transition between different states (e.g. time for a healthy individual, with a given risk factor profile, to develop diabetes)
- Death rates (e.g. Natural death rate, background mortality, death rate associated to complications).

3 Equations

The dynamics of the model are represented by the 5 set of equations which summarizes the different states at different stages: diagnosed, undiagnosed, treated patients in phase 1, treated patients in phase 2, and the disease severity management stage. Each state variable is denoted by index i and t, where i defines an age group (e.g. 0-10, 10-20, etc.) and t is the time variable.

The first set of two equations define the dynamics of the population at risk who receives a risk factor reduction intervention (A), and those who do not receive such intervention (ANRFR).

$$\frac{dA}{dt} = i_3 * S_{PD\_A} * PD + i_3 * S_{ND\_A} * ND + R_{UND\_A*} S_{UND\_A} * UND -$$
$$(i_1 * S_{A\_SUS} + i_1 * S_{A\_ND} + (1 - i_1) * S_{A\_UND} + (1 - i_1) * S_{A\_UD} * A$$

$$\frac{dANRFR}{dt} = i_3 * S_{PD\_A} * PD + i_3 * S_{ND\_A} * ND +$$
$$R_{UND\_A*} S_{UND\_A} * UND$$
$$+ (1 - i_3) * S_{ND\_ANRFR} * ND + (1 - i_3) * S_{PD\_ANRFR} * PD$$
$$+ R_{UND\_ANRFR} * S_{UND\_ANRFR} * UND$$
$$- (i_1 * S_{ANRFR\_SUS} + i1 * S_{ANRFR\_ND}$$
$$- (1 - i_1) * S_{ANRFR\_UND} - (1 - i_1) * S_{ANRFR\_UD}) * ANRFR$$

Population at risk have the opportunity to be screened. If a given individual is detected with abnormal high values of glucose they get re-tested. Based on their glucose results, individuals are classified according to their diabetic outcomes: non-diabetic (ND), pre-diabetic (PD), diabetic under phase 1 and phase 2 (D1, D2).

$$\frac{dSUS}{dt} = i_1 * S_{A\_SUS} * A + i_1 * S_{ANRFR\_SUS} * ANRFR$$
$$- (S_{ND} + S_{PD} + S_{D1} + S_{D2}) * i_2 * SUS$$

$$\frac{dND}{dt} = i_1 * S_{A\_ND} * A + i_1 * S_{ANRFR\_ND} * ANRFR + i2 * S_{ND} * SUS$$
$$- (i_3 * S_{ND\_A} + (1 - i_3) * S_{ND\_ANRFR}) * ND$$

$$\frac{dPD}{dt} = i_2 * S_{PD} * SUS - (i_3 * S_{PD\_A} + (1 - i_3) * S_{PD\_ANRFR}) * PD$$

$$\frac{dD1}{dt} = i_2 * S_{D1} * SUS$$
$$- (R_{D1HC} * S_{D1HC} + R_{D1LC} * S_{D1LC} + R_{D1U} * S_{D1U}) * D1$$
$$- (i_3 * S_{ND\_A} + (1 - i_3) * S_{ND\_ANRFR}) * ND$$

$$\frac{dD2}{dt} = i_2 * S_{D12} * SUS$$
$$- (R_{D2HC} * S_{D2HC} + R_{D2LC} * S_{D2LC} + R_{D2U} * S_{D2U}) * D2$$

After being diagnosed, the population can either receive a high and a low cost treatment or remain uncontrolled. Notice how patients who enter to D1HC or D2HC stay there and stop disease progression, contrary to D1LC and D2LC, simulating the treatment heterogeneity. This is summarize in the following equations:

$$\frac{dD1HC}{dt} = R_{D1HC} * S_{D1HC*D1}$$

$$\frac{dD1LC}{dt} = R_{D1LC} * S_{D1LC*D1} - R_{D1LC\_D2LC} * S_{D1LC\_D2LC} * D1LC$$

$$\frac{dD1U}{dt} = R_{D1U} * S_{D1U} * D1 - R_{D1U\_D2U} * S_{D1U\_D2U} * D1U$$

$$\frac{dD2HC}{dt} = R_{D2HC} * S_{D2HC*D1}$$

$$\frac{dD2LC}{dt} = R_{D2LC} * S_{D2LC} * D2 + R_{D1LC\_D2LC} * S_{D1LC\_D2LC} * D1LC$$
$$- R_{D2LC\_M} * S_{D2LC\_M} * D2LC$$

$$\frac{dD2U}{dt} = R_{D1U\_D2U} * S_{D1U\_D2U} * D1U + R_{D2U} * S_{D2U} * D2 -$$
$$(R_{D2U\_M} * S_{D2U\_M} + R_{D2U\_CVD} * S_{D2U\_CVD} +$$
$$R_{D2U\_DNEPH} * S_{D2U\_DNEPH}$$
$$+ R_{D2U\_DNEUR} * S_{D2U\_DNEUR} + R_{D2U\_DR} * S_{D2U\_DR}) * D2U$$

Population at risk who do not have access to screening are considered as undiagnosed diabetic (UD) and undiagnosed non-diabetic (UND).

$$\frac{dUND}{dt} = (1 - i_1) * S_{A\_UND} * A + (1 - i_1) * S\_ANRFR_UND * ANRFR$$
$$- (R_{UND\_A} * S_{UNDA}$$
$$+ R_{UND\_ANRFR} * S_{UND\_ANRFR} + R_{UND\_UD} * S_{UND\_UD}) * UND$$

$$\frac{dUD}{dt} = (1-i_1) * S_{A_UD} * A + (1-i_1) * S_{ANRFR\_UD} * ANRFR$$
$$+ R_{UND\_UD} * S_{UND\_UD} * UND - R_{UD\_M} * S_{UD\_M} * UD$$
$$- (R_{UD\_DR} * S_{UD\_DR} + R_{UD\_DNEUR} * S_{UD\_DNEUR}$$
$$+ R_{UD\_DNEPH} * S_{UD\_DNEPH} + R_{UD\_CVD} * S_{UD\_CVD}) * UD$$

Finally, diabetic population may be monitored for disease progression. Monitored and unmonitored population develop complications: cardiovascular disease, diabetic neuropathy, diabetic nephropathy and diabetic rheumatoid.

$$\frac{dM}{dt} = R_{UD\_M} * S_{UD\_M} * UD$$
$$+ R_{D2U\_M} * S_{D2U\_M} * D2U + R_{D2LC\_M} * S_{D2LC\_M} * D2LC$$
$$- (R_{M\_CVD} * S_{M\_CVD} + R_{M\_DNEPH} * S_{M\_DNEPH} +$$
$$R_{M\_DNEUR} * S_{M\_DNEUR} + R_{M\_DR} * S_{M\_DR}) * M$$

$$\frac{dM_{CVD}}{dt} = R_{M\_CVD} * S_{M\_CVD} * M - \mu_{1,CVD} * UD_{CVD} - \mu * M_{CVD}$$

$$\frac{dM\_DNEPH}{dt} = R_{M\_DNEPH} * S_{M\_DNEPH} * M$$
$$- \mu_{1,DNEPH} * UD_{DNEPH} - \mu * M_{DNEPH}$$

$$\frac{dM\_DNEUR}{dt} = R_{M\_DNEUR} * S_{M\_DNEUR} * M$$
$$- \mu_{1,DNEUR} * UD_{DNEUR} - \mu * M_{DNEUR}$$

$$\frac{dM\_DR}{dt} = R_{M\_DR} * S_{M\_DR} * M - \mu_{1,DR} * UD_{DR} - \mu * M_{DR}$$

$$\frac{dUD\_CVD}{dt} = R_{D2U\_CVD} * S_{D2U\_CVD} * D2U$$
$$+ R_{UD\_CVD} * S_{UD\_CVD} * UD$$
$$- \mu_{2\_CVD} * UD_{CVD} - \mu * UD_{CVD}$$

$$\frac{dUD\_DNEPH}{dt} = R_{D2U\_DNEPH} * S_{D2U\_DNEPH} * D2U$$
$$+ R_{UD\_DNEPH} * S_{UD\_DNEPH} * UD$$
$$- \mu_{2\_DNEPH} * UD_{DNEPH} - \mu * UD_{DNEPH}$$

$$\frac{dUD\_DNEUR}{dt} = R_{D2U\_DNEUR} * S_{D2U\_DNEUR} * D2U + R_{UD\_DNEUR} * S_{UD\_DNEUR} * UD - \mu_{2\_DNEUR} * UD_{DNEUR} - \mu * UD_{DNEUR}$$

$$\frac{dUD\_DR}{dt} = R_{D2U\_DR} * S_{D2U\_DR} * D2U + R_{UD\_DR} * S_{UD\_DR} * UD - \mu_{2\_DR} * UD_{DR} - \mu * UD_{DR}$$

4 R-Shiny App epidemiological features.

The R-Shiny app summarizes the model outcomes in a user-friendly interface. At present, the app allows users to: 1) change the value of key parameters including prevention strategy coverage, screening coverage, treatment and monitoring; and 2) observe the epidemiological (i.e the burden of different states of diabetes and coverage of care.) and economic outcomes

Figure 1 and 2 show an app preview. The first three graphs show: 1) A 30 year simulation of the diabetic status of the population; 2) the associated health outcomes in terms of the population who develop complications; and 3) the population distribution at the end of the period.
For simplicity, we have assumed so far that μ, μ_1 and μ_2 are equal to zero (i.e. the population does not die). The fourth figure summarizes the distribution of costs and benefits. The costs include: screening, risk factor reduction, treatment and monitoring. The benefits are years of life lost savings, presenteeism and absenteeism savings. All measures are expressed in net present value, which is computed in the following way:

$$NPV_{costs} = \sum_{t=0}^{T} \frac{Costs_t}{(1+i_t)^t}$$

$$NPV_{benefits} = \sum_{t=0}^{T} \frac{Benefits_t}{(1+i_t)^t}$$

where i_t represents the interest rate of a risk-free investment and T is the last period in the simulation.

Based on the Net present values of the interventions, the app displays a pie chart that shows the percentages of total benefits and costs.

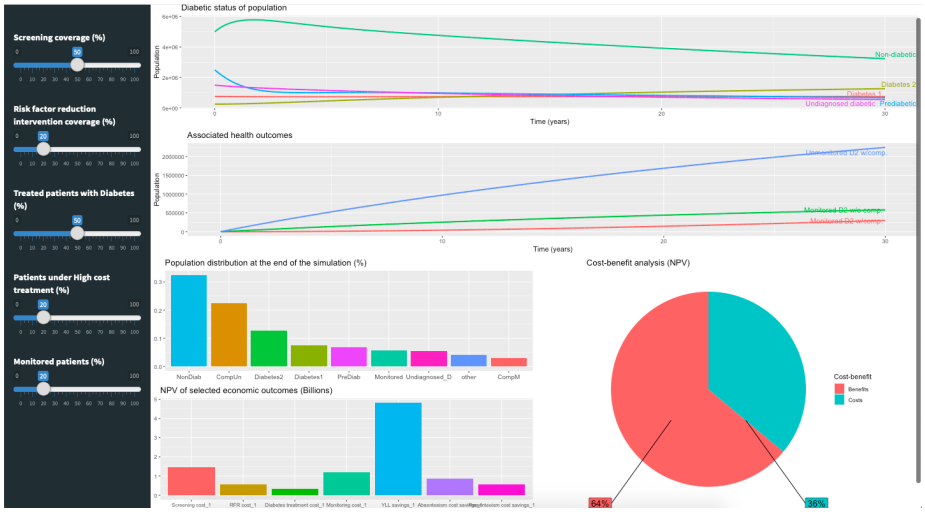


Figure 1: system dynamics with almost all interventions set to 20%

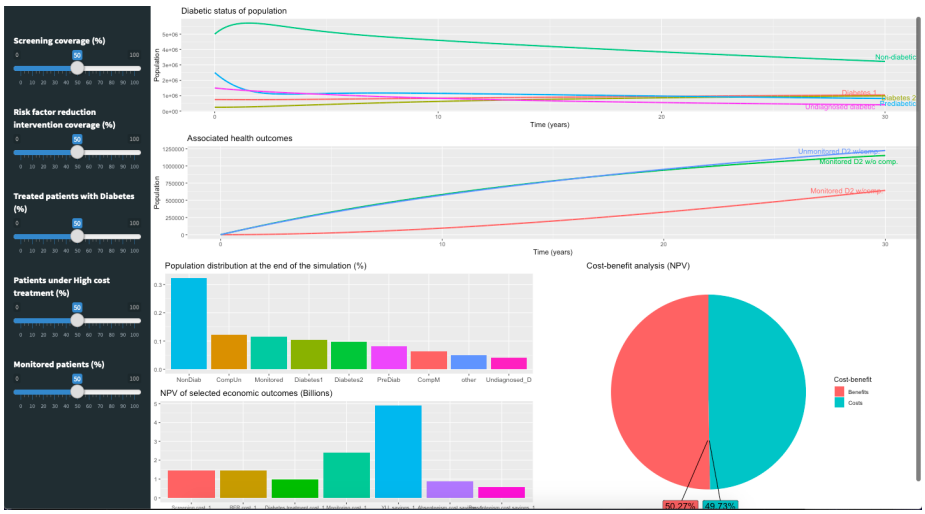


Figure 2: system dynamics with all interventions set to 50%

5 Feedback on developments of the app.

5.1 Peer review by David Watkins.

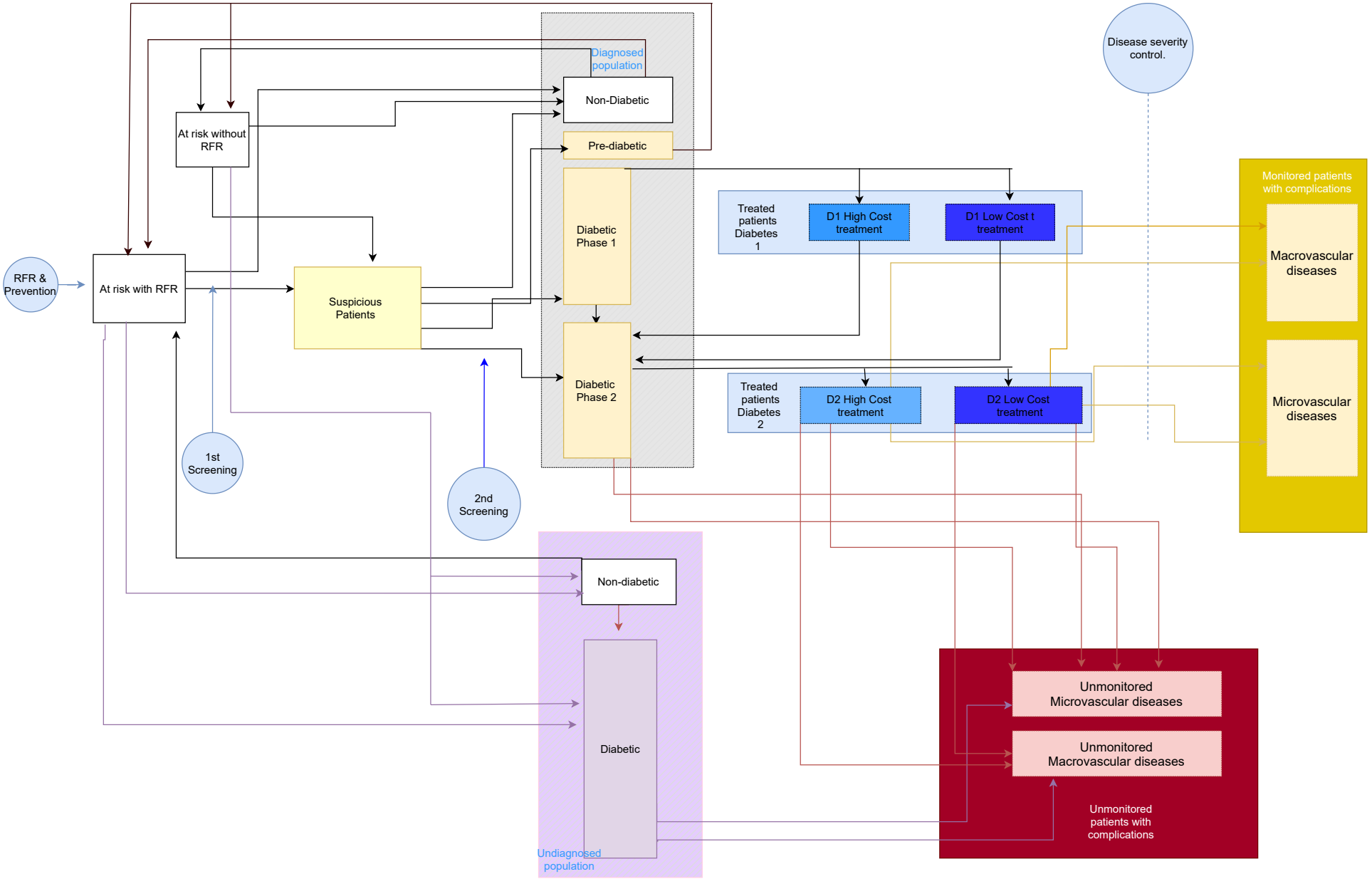
Disease progression and diabetes care continuum should be included in model:

- Need to refine relationship between stakeholders/audiences, particular financing instruments, and different outcomes/impacts
- What is the best way to frame value proposition around diabetes?
- Model currently captures early-stage diabetes well and makes sense
- Balanced approach in early and end stages of disease is needed as to not overwhelm computers
- Granularities as to what is happening in the at risk/screening may not be well marked in data (e.g. argument for simplicity with data needs)
- Complications to consider in the model:
    1. Outcomes are correlated within patients: Those who develop neuropathy also develop retinopathy they are not totally independent from one and other.
    2. Breakdown of end stage complications.
    3. OI and cost savings include access to treatments – benefits of prevention depend on the treatment landscape and this includes consideration of competing risks
    4. Health outcomes: Complex relationship with people who die of diabetes and people with diabetes who die of CVD as these compete with each other through background mortality.
    5. Background mortality with two compartments plus inclusion of CVD background mortality in the model.

5.2 Comments from HFI team.

- Summarize and present clear metrics to investors.
- Integrate metrics based on the economic impact to the population: health savings within the housholds; number of people saved from poverty?.
- Instead of using absolute figures to discuss epidemiological outcomes, it could be useful for users to understand in relative terms (i.e. percentages of people diagnosed with cancer).
- Include friendlier figures to summarize results (E.g. pie charT)
- Should the simulation be based on total population or population at risk ?

- What would investors want to see? How can we integrate shorter term goals to appeal to investors?
- Different ways to present data: some metrics could be displayed through pie charts


Diagnosed population
Non-Diabetic
Pre-diabetic
At risk without RFR
Disease severity control.
Monitored patients with complications
Diabetic Phase 1
Treated patients Diabetes 1
D1 High Cost treatment
D1 Low Cost t treatment
Macrovascular diseases
RFR & Prevention
At risk with RFR
Suspicious Patients
Microvascular diseases
Diabetic Phase 2
Treated patients Diabetes 2
D2 High Cost treatment
D2 Low Cost treatment
1st Screening
2nd Screening
Non-diabetic
Unmonitored Microvascular diseases
Diabetic
Unmonitored Macrovascular diseases
Unmonitored patients with complications
Undiagnosed population