



POWER2DM

“Predictive model-based decision support for diabetes patient empowerment”

Research and Innovation Project

PHC 28 – 2015: Self-management of health and disease and decision support systems based on predictive computer modelling used by the patient him or herself

POWER2DM D2.5

Mockups for GUI Components related with Visualization of Predictions and Simulations

Due Date: 30th September 2016 (M8)
Actual Submission Date:
Project Dates: Project Start Date: February 01, 2016
 Project End Date: July 31, 2019
 Project Duration: 42 months
Deliverable Leader: SRDC

Project co-funded by the European Commission within H2020 Programme (20015-2016)		
Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Document History:

Version	Date	Changes	From	Review
V0.1	25.07.2016	Deliverable template and assignments, User interfaces of existing systems Suggestions for mockups	SRDC, IDK and SAS	ALL
V0.2	11.08.2016	Mockups for predictions	SRDC, TNO	ALL
V0.3	22.08.2016	Descriptions of MT2D-Marvel, Input to 3.2.1 and 3.2.2 Input for 3.2.4.5	TNO SRDC	ALL
V1.0	27.09.2016	Compilation of deliverable for submission	SRDC	
V1.1	29.09.2016	Final edits MT2D-Marvel, typos	TNO	

Contributors (Benef.) Tuncay Namlı (SRDC)
Suat Gönül (SRDC)
Javier Delgado Lista (SAS)
Lutz Vogt (IDK)
Albert De Graaf (TNO)
Jacob K. Sont (LUMC)

Responsible Author Tuncay Namlı **Email** tuncay@srdc.com.tr

POWER2DM Consortium Partners

Abbv	Participant Organization Name	Country
TNO	Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek	Netherlands
IDK	Institute of Diabetes "Gerhardt Katsch" Karlsburg	Germany
SRDC	SRDC Yazilim Arastirma ve Gelistirme ve Danismanlik Ticaret Limited Sirketi	Turkey
LUMC	Leiden University Medical Center	Netherlands
SAS	SAS Servicio Andaluz de Salud	Spain
SRFG	Salzburg Research Forschungs Gesellschaft	Austria
PD	PrimeData	Netherlands
iHealth	iHealth EU	France

TABLE OF CONTENTS

Table of contents	4
1 Introduction	5
1.1 Purpose and Scope	5
1.2 References	5
1.3 Definitions and Acronyms	5
2 Existing Systems and their User Interfaces for Prediction/Simulation Visualization	6
2.1 KADIS System and Existing User Interfaces	6
2.2 M2TD-Marvel Predictions	12
2.1 Risk Score Models	16
2.1.1 UKPDS	16
2.1.2 Advance Risk Engine	17
2.1.3 QRisk2-2015	19
2.1.4 Framingham	20
2.1.5 T1D Major Outcomes Model	20
3 POWER2DM UI Designs for Prediction/Simulation Visualization	21
3.1 Physician Perspective (UIs used in Shared Decision Making Phase)	21
3.1.1 Treatment Planning with KADIS View	21
3.1.2 KADIS Planned Blood Glucose Profile vs Actual/Estimated BG Measurements	23
3.1.3 Risk Score Compass Panel	24
3.1.4 Mid-term Predictions/Simulation Panel (MT2D-Marvel based)	25
3.1.5 Risk Score Predictions/Simulation Panel	25
3.2 Patient Perspective (UIs for Self-Management Phase)	25
3.2.1 General Issues to show predictions to Patient	25
3.2.2 POWER2DM Main Principles and Approach to these issues	26
3.2.3 Mockups for Patient Centered Visualizations of Predictions	27

1 Introduction

1.1 Purpose and Scope

The purpose of this deliverable is to document the results of trans-disciplinary HCI research for patient-centred visualizations, representations and user interfaces for the predictions and simulations provided by POWER2DM. In addition to providing an effective easy-to-use UI, we also aim to describe the rationale behind the predictions and suggested actions to the users especially to patients, based on the knowledge (uncertainty, specificity, significance of parameters in the model) attached to these predictions (coming from the predictive models, data quality assessments, and evidence based clinical rules and guidelines).

Section 2 provides brief information about the prediction models (to be used within the scope of POWER2DM) and their existing GUIs used by physicians and specialists to show what is available. This includes the KADIS model and its usage within the TeleDIAB system in Germany in Karlsburg Diabetes Center, proof of concept user interfaces developed and used in the scope of several projects for M2TD-Marvel model, and existing UIs for several risk score models that may be considered within the scope of POWER2DM.

Section 3 provides the mockup GUI designs for the related user interfaces that show the results of predictions/simulations by using these existing models. Section 3.1 provides the mockups for related interfaces for POWER2DM Shared Decision Making Applications which will be used by physicians. On the other hand, Section 3.2 provides the mockups from patient perspective; the user interfaces to be used as a part of POWER2DM Self-Management Support System (SMSS). It also analyses the general issues to show the predictions to patient and POWER2DM's general approach and principle to overcome these issues.

1.2 References

- POWER2DM Description of Work (Proposal)
- D1.1 User Requirements and Use Case Scenarios
- D1.2 Requirements Specification of the POWER2DM Architecture

1.3 Definitions and Acronyms

Table 1 List of Abbreviations and Acronyms

Abbreviation/ Acronym	DEFINITION
CGM	Continuous glucose measurement
SMBG	Self-monitoring blood glucose
GUI	Graphical User Interface
UKPDS	United Kingdom Prospective Diabetes Study
T1D	Type 1 Diabetes
OM	Outcome Model
BG	Blood glucose
SDM	POWER2DM Shared Decision Making Application
CVD	Cardiovascular Disease
SMSS	POWER2DM Self-Management Support System

2 Existing Systems and their User Interfaces for Prediction/Simulation Visualization

2.1 KADIS System and Existing User Interfaces

The platform where KADIS functionality was embedded is TeleDIAB® system and provided as a service by “Diabetes Service Center Karlsburg (DCC)” (operated by the POWER2DM partner IDK) in Germany. The functionality is available as a web based service with two main user interfaces. One of them is for entering basic data and for the analysis of the results of a 3-day monitoring period, either performed by Continuous Glucose Monitoring (CGM) or Self-monitoring Blood Glucose (SMBG), as shown in Figure 2. In case of CGM, glucose values were uploaded to KADIS from an export file mostly generated by a software tool coming with the CGM system or as export and download from the platform of the CGM company (e.g. careLink, medtronic). Currently, there is no IT system provided to patient for logging the required values (medication/insulin intakes, meals, etc). A printed data collection sheet as shown in Figure 1 is distributed to the patient to log these values for the 3-day monitoring period. Then the specialist in the diabetes centre enter the values manually over the GUI shown in **Figure 2**.

Usage of TeleDIAB®/KADIS® is supported for different user groups; the specialists in diabetes service centre itself, physicians and patients. However, current web based application is only used by the specialists in the diabetes service centre. Physicians in Germany prefer the KADIS® report (print out). However, IDK is pushing for the moment to use the medical network of the physician association in Germany (Kassenärztliche Vereinigung), the KV safe net, for sending the KADIS report as an encrypted PDF-file directly to the physicians practice computer system.

After the registration of data for the 3-day monitoring period, the specialists in DCC work on the data to identify the Metabolic Fingerprint for the patient. This is semi-automated process supported by several tools in the DCC. When the Metabolic Fingerprint is ready, experienced diabetologists, closely cooperating with the DCC, works interactively with the platform as shown in the **Figure 3** to prepare the KADIS reports. As shown in the figure, the interface shows the measurements from the 3-day monitoring period (the dots), the identified Metabolic Fingerprint (the grey line). The diabetologist can try several recommended therapies to see the change in daily blood glucose profiles and find the optimum one. In this way, up to 3 recommendations simulated with KADIS can be involved in the final KADIS® report.

In the KADIS® report, there are two different graphs, one for diagnosis of the actual situation as shown in **Figure 4**, second with the simulation results as well as recommendations (treatment plan) as shown in **Figure 5**. Currently, the KADIS® Report is provided in German language only, but the templates for the user interface could be translated to other languages too. From the perspective of doctors, the KADIS® Report is considered to be extremely helpful, which is also true for the analysis and graphs. Therefore, the graphs could be serve as a template for the user interface.



Blutzucker-Messplan und Selbstkontrolldaten

Patient-ID: _____



Die Mahlzeiten bitte als Kategorie A, B, C oder D angeben !

- A wenig** (0-2 BE) wenig = 1 Scheibe Brot oder 1 Joghurt oder 1 Apfel oder Gemüse oder 1 kl. Bier
- B mittel** (3-4 BE) mittel = 1 Brötchen mit Marmelade oder 2 Scheiben Brot oder 1 Banane oder Fleisch/Fisch mit Gemüse + wenig Kartoffeln
- C viel** (5-6 BE) viel = 1/2 Pizza oder 1 Döner oder Schnitzel mit 3-4 Kartoffeln und Mischgemüse oder großer Obstsalat oder 2 Brötchen mit Marmelade oder 2 Stk. Kuchen oder > 3 Bier
- D sehr viel** (>7 BE) sehr viel = 3 belegte Brötchen oder 1 Pizza oder Wiener Schnitzel mit Pommes oder Dönerteller oder Menu Mc Donalds etc.

Bitte das Datum eintragen !

nachts	Frühstück			Mittag			Abendessen			nachts	
	0 - 5 Uhr	vor dem Frühstück	1 Stunde nach dem Frühstück	2 Stunden nach dem Frühstück	vor dem Mittagessen	1 Stunde nach dem Mittagessen	2 Stunden nach dem Mittagessen	vor dem Abendessen	1 Stunde nach dem Abendessen		2 Stunden nach dem Abendessen
Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____
BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____
Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____

Tag 1
Datum _____

Uhrzeit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	0	
ankreuzen	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	
Insulin (Welches, Dosis)																									
Tabletten (Welche, Anzahl)																									
Mahlzeit Kategorie																									

Bitte das Datum eintragen !

nachts	Frühstück			Mittag			Abendessen			nachts	
	0 - 5 Uhr	vor dem Frühstück	1 Stunde nach dem Frühstück	2 Stunden nach dem Frühstück	vor dem Mittagessen	1 Stunde nach dem Mittagessen	2 Stunden nach dem Mittagessen	vor dem Abendessen	1 Stunde nach dem Abendessen		2 Stunden nach dem Abendessen
Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____	Uhrzeit: _____
BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____	BZ: _____
Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____	Wert: _____

Tag 2
Datum _____

Uhrzeit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	0	
ankreuzen	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	15	30	45	
Insulin (Welches, Dosis)																									
Tabletten (Welche, Anzahl)																									
Mahlzeit Kategorie																									

© 2015 - Diabetes Service Center GmbH, Karlsruhe

Figure 1 KADIS Data Collection Sheet

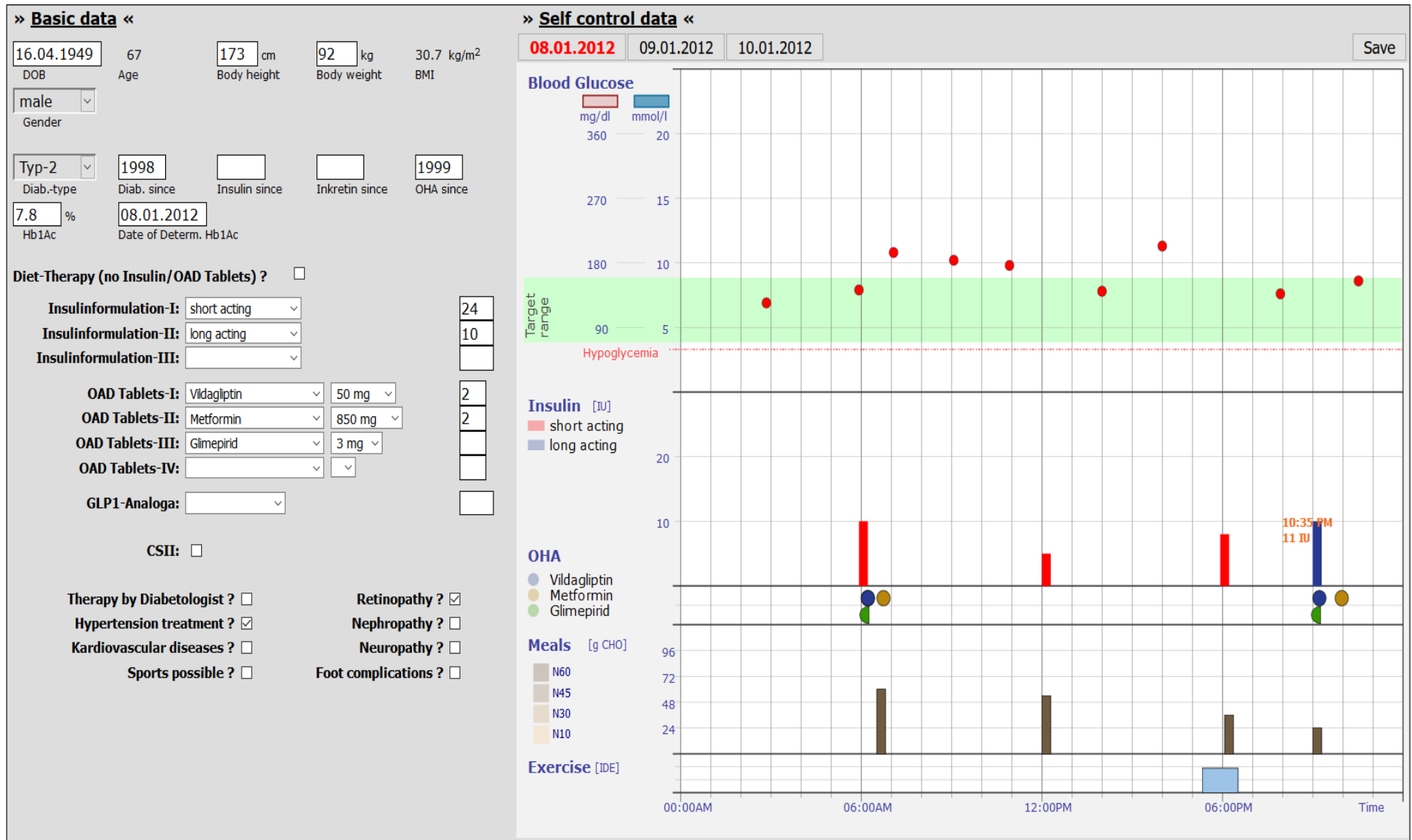


Figure 2 KADIS Web Interface - Data Entry

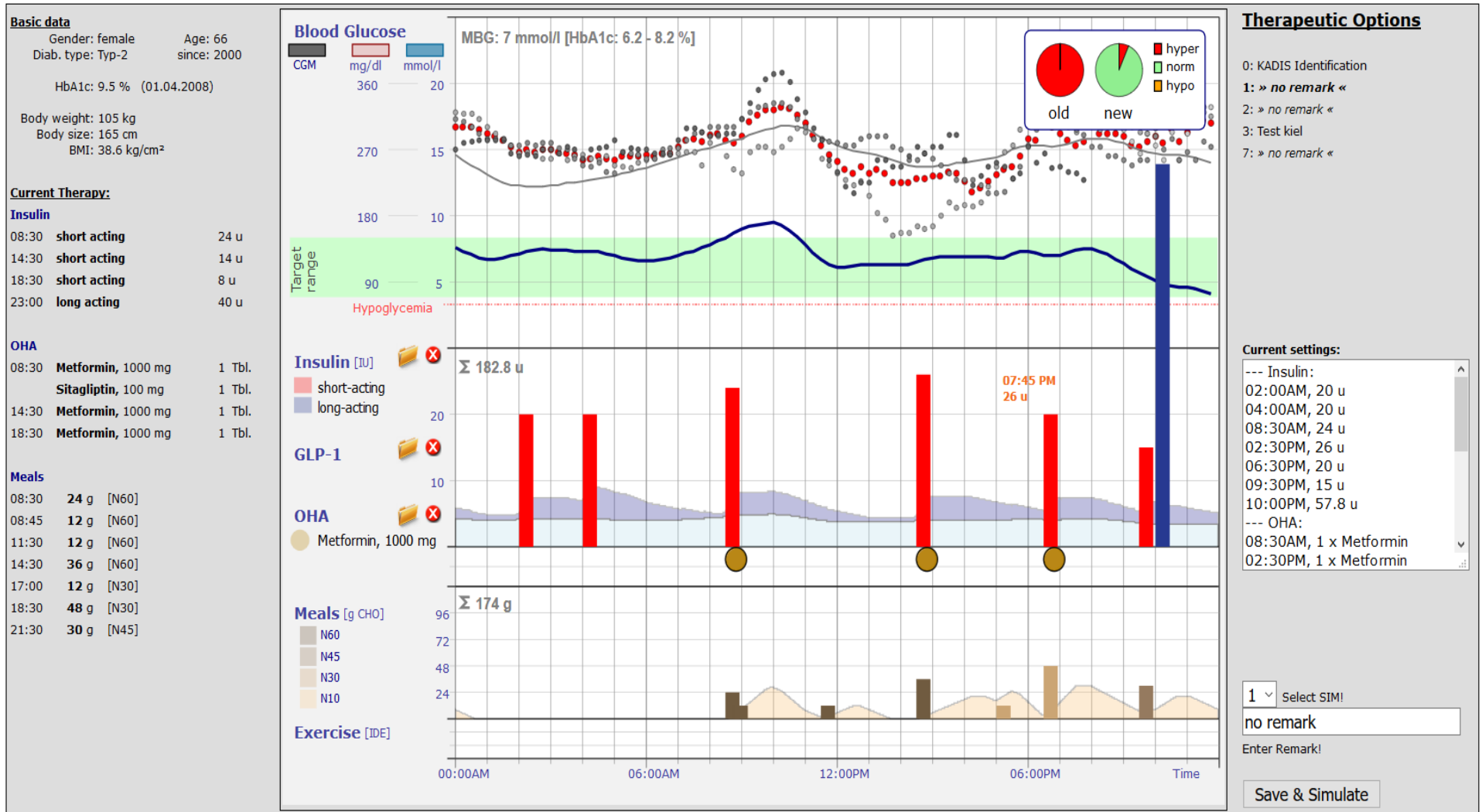
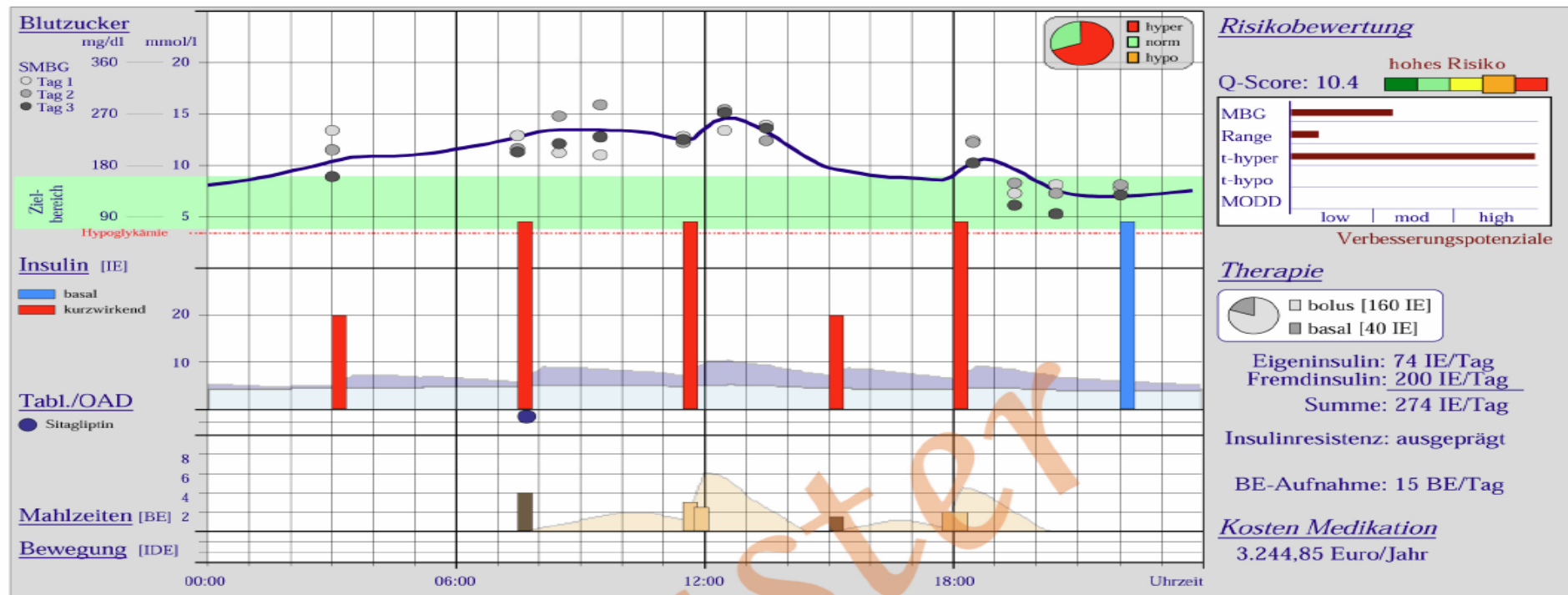


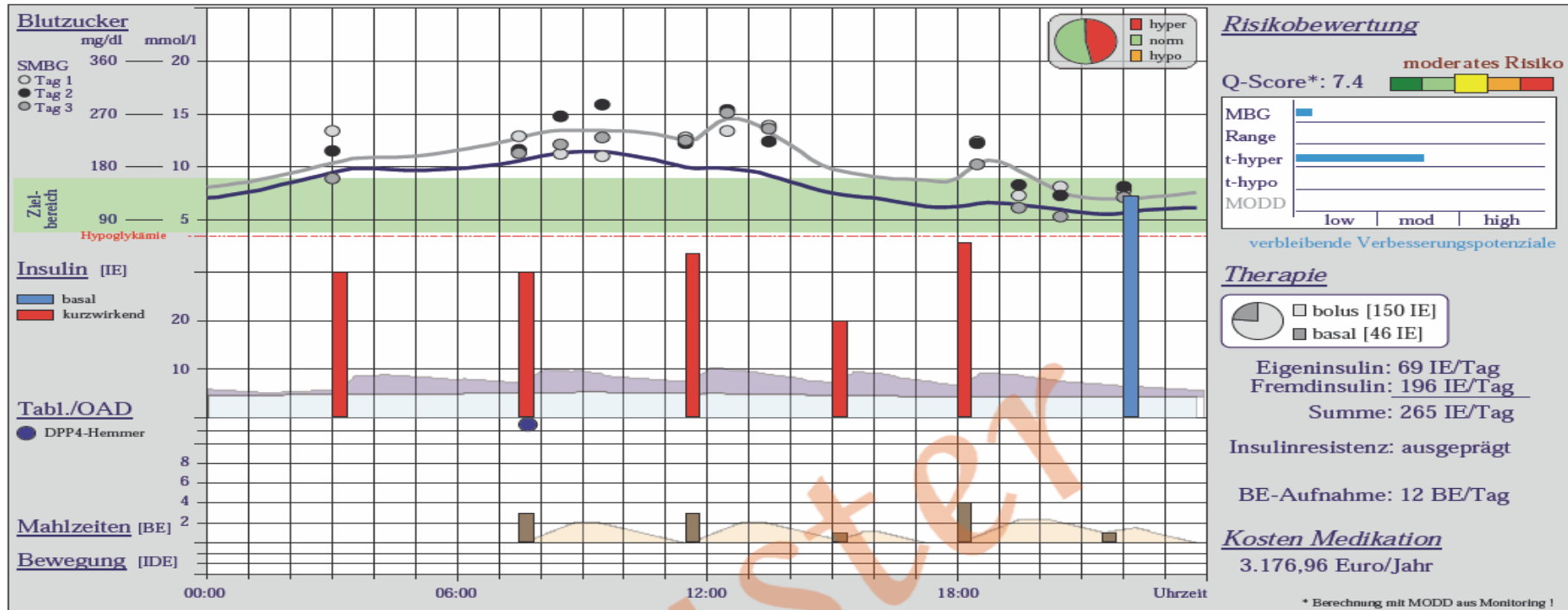
Figure 3 KADIS Interface – Report Generation

Tabletten/OAD-Insulin Kombinationstherapie



	Frühstück	Zwischen- mahlzeit	Mittag	Zwischen- mahlzeit	Abendbrot	Spätstück	insg.
Mahlzeiten - BE	4 [07:30]		3 2.5 [11:30][11:45]	1.5 [15:00]	2 2 [17:45][18:00]		15
Insulin							
NovoRapid	20 40 [03:00][07:30]		40 [11:30]	20 [15:00]	40 [18:00]		160
Protaphan						40 [22:00]	40
OAD							
Januvia, 100 mg	1 [07:30]						1

Figure 4 KADIS Diagnosis Report - Metabolic Fingerprint



	Frühstück	Zwischenmahlzeit	Mittag	Zwischenmahlzeit	Abendbrot	Spätstück	insg.
Mahlzeiten - BE	3 [07:30]		3 [11:30]	1 [15:00]	4 [18:00]	1 [21:30]	12
Insulin							
basal						46 [22:00]	46
kurzwirkend	30 30 [03:00][07:30]		34 [11:30]	20 [15:00]	36 [18:00]		150
OAD							
DPP4-Hemmer, 100 mg	1 [07:30]						1

Figure 5 KADIS Report - Simulation, Recommendation, Prediction

2.2 M2TD-Marvel Predictions

The MT2D-Marvel model is a model based on a causal loop diagram of diabetes development. It was originally developed by partner TNO and was validated in EU-FP7 project MISSION-T2D. The rationale of the model is described in the deliverables of MISSION-T2D.

Figure 5 shows the actual causal loop diagram that is the basis of the model. Control variables are the ones that can be influenced by lifestyle choices and that will have effects on health parameters associated with diabetes.

Figure 6 shows an example of the interactive GUI of the TNO-proprietary MARVEL software tool for shared model building. Sliders can be shifted to rapidly simulate different lifestyle scenarios. Different sets of variables can be selected for display. Display type can be chosen as curves or radar chart.

Figure 7 shows the current implementation of the MT2D-Marvel simulation visualization in Patient Coach to be used during the shared decision making phase. BMI, fasting glucose and insulin sensitivity are pre-set as goal variables. The inputs of the current simulation are depicted as text on top of the figure panels. The time window can be chosen by the user (1 year to 6 years). To start a different simulation, textual inputs for the lifestyle parameters calorie intake and total energy expenditure corresponding to a given physical activity level (both in kcal/day) need to be specified and a “start simulation” button clicked. Once an acceptable simulation (i.e., both for physician with respect to outcomes, and for patient with respect to lifestyle changes) is produced, the curve plus parameters can be stored as treatment plan scenario for future reference (cf. Figure 8). The current implementation in Patient Coach only allows to vary calorie intake and energy expenditure.

Figure 8 shows the current implementation of the MT2D-Marvel Prediction/Simulation visualization in Patient Coach used for shared decision making. BMI is chosen as an example goal variable. Two curves in the same panel are shown, for (1) prediction of the current lifestyle scenario and (2) simulation of the treatment plan scenario.

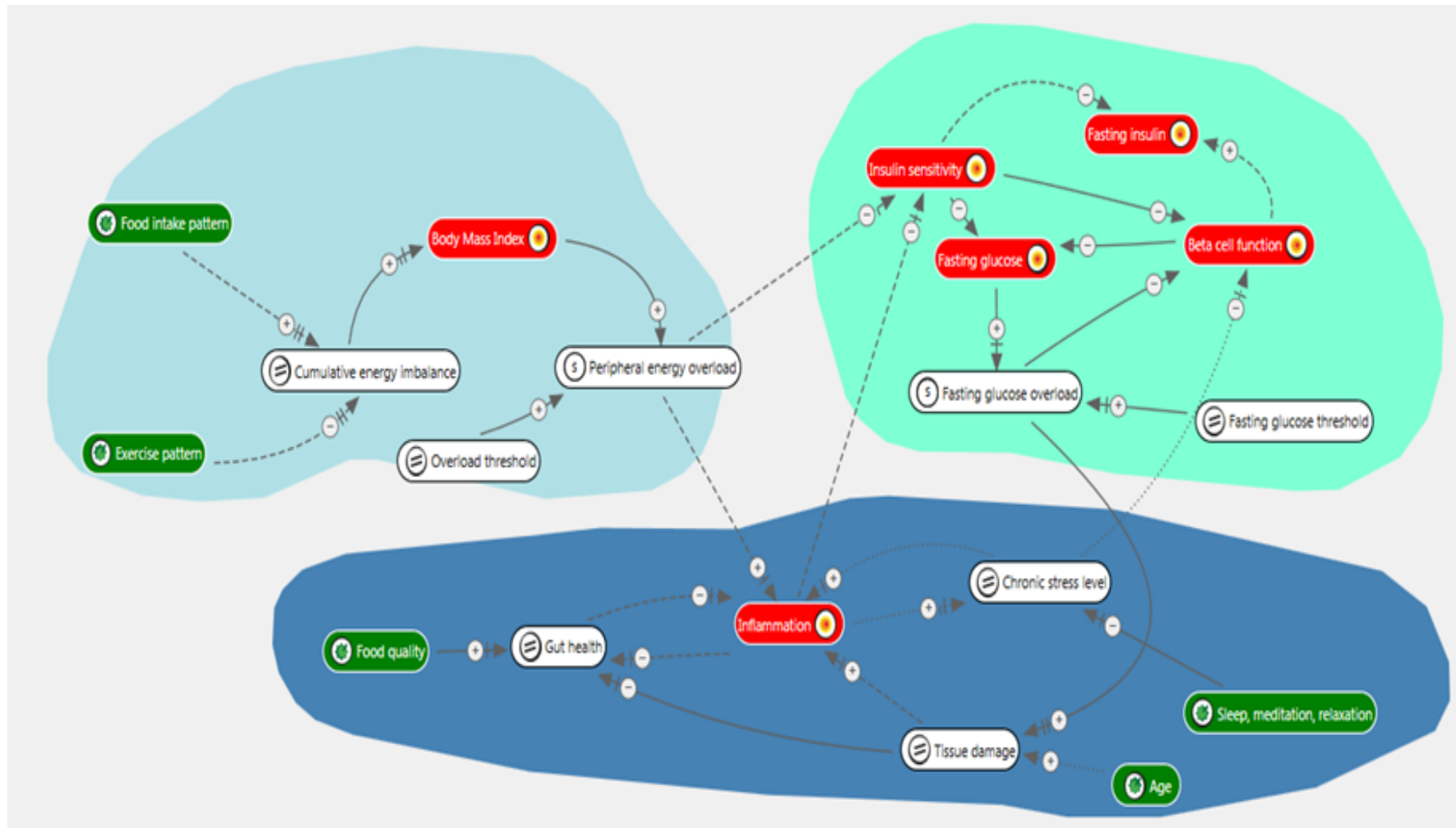


Figure 6 M2TD-Marvel model network topology. Coloured clouds symbolize different physiological domains: body energy balance (light blue), glucose homeostasis (light green) and miscellaneous processes (dark blue). Variables in green fields denote control (input) variables. Variables in red fields denote goal (outcome) variables. Variables in white field denote ordinary variables in the model. Goal variables can be freely chosen according to user relevance from all variables except from control variables.

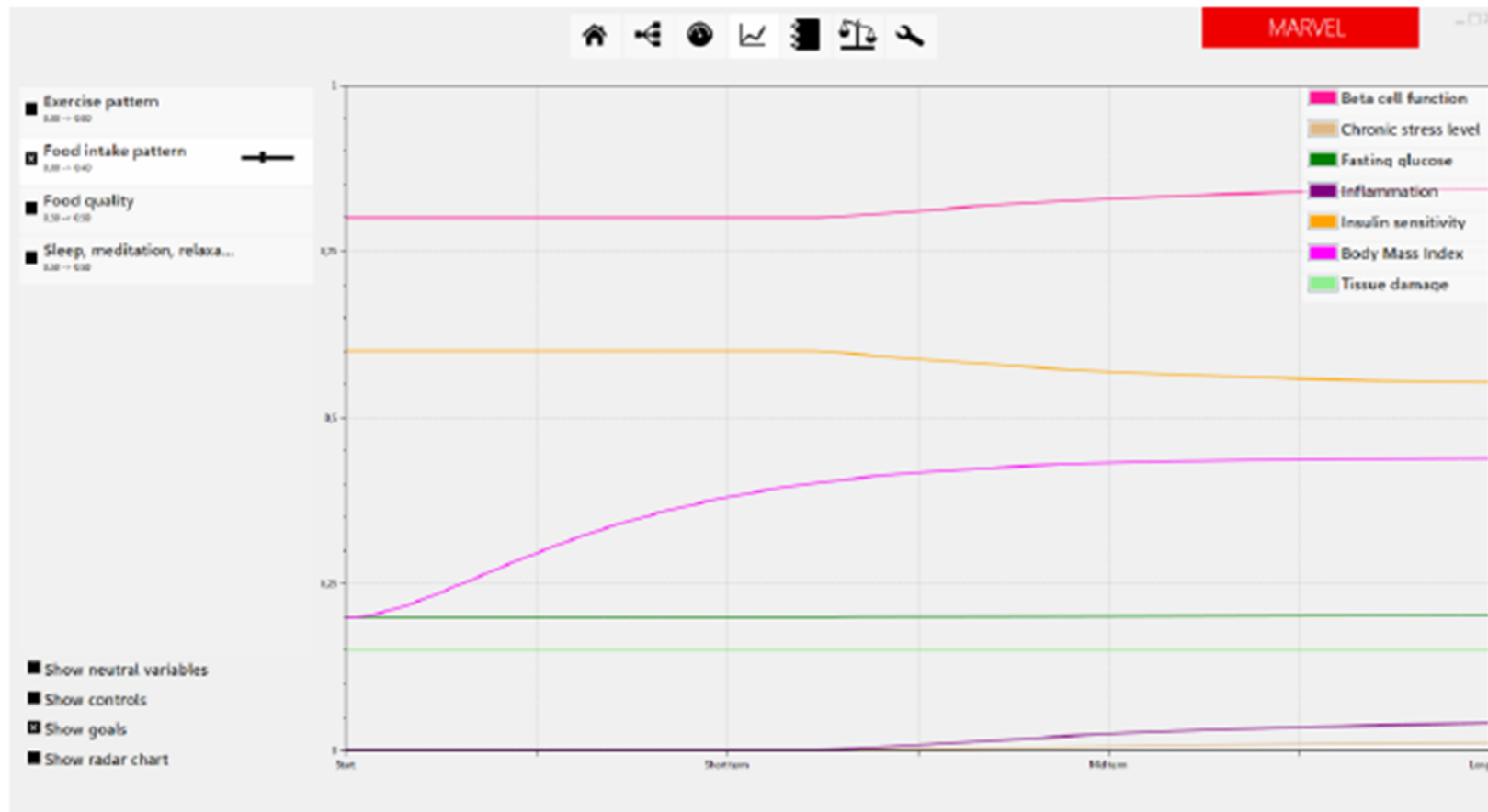


Figure 2.3.7. Healthy lean subtype, 476 kcal per day overfeeding

Figure 7 TNO proprietary software tool MARVEL Graphical User Interface for Predictions. Sliders in the top left panel allow to vary settings of control variable. The set of displayed variables and the type of display (curves or radar chart) can be chosen by checking/unchecking boxes in the lower left panel.

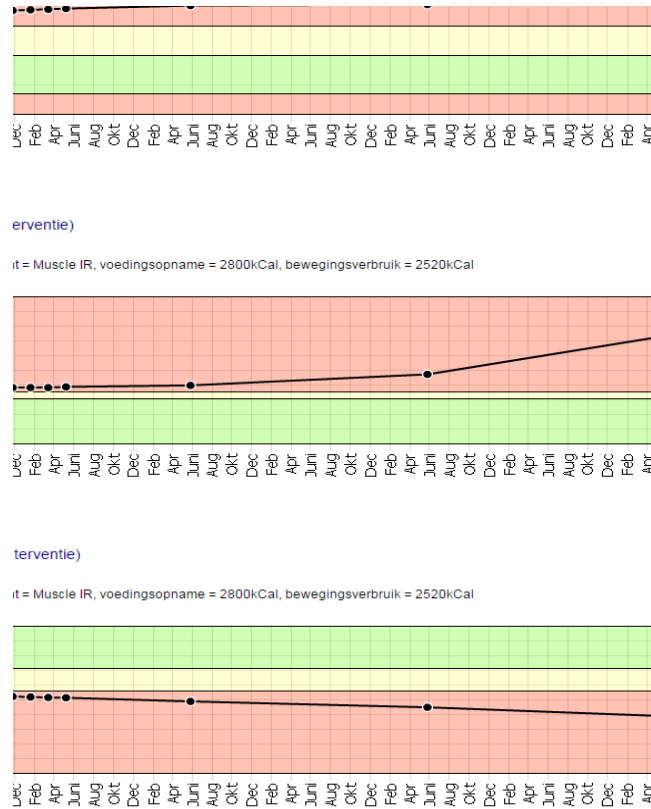


Figure 8. MT2D-Marvel Simulation Display Implementation in PatientCoach – Six-year simulations of selected goal variables BMI, fasting glucose and insulin sensitivity (top to bottom) for a person with starting values judged typical for a muscle-insulin resistant early Type-2 diabetic patient, showing expected consequences of a lifestyle modification corresponding to a change towards 280 kcal/day positive energy balance.

› Body Mass Index

Huidige status: type patient = Hepatic IR, voedingsopname = 3250kCal, bewegingsverbruik = 3000kCal
Interventie: type patient = Hepatic IR, voedingsopname = 2500kCal, bewegingsverbruik = 3000kCal

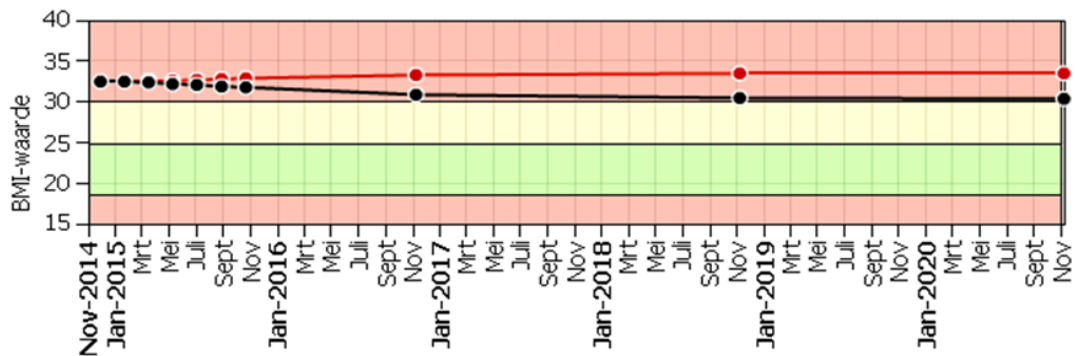


Figure 9 MT2D-Marvel Prediction-Simulation Display Implementation in PatientCoach - BMI Prediction (red curve) for continuation of the current lifestyle with 250 kcal/day positive energy balance, and simulation (black curve) for a treatment plan corresponding to 500 kcal/day negative energy balance.

2.1 Risk Score Models

2.1.1 UKPDS

UKPDS Outcomes Model (<http://www.dtu.ox.ac.uk/outcomesmodel/>) estimates the total lifetime burden of disease in populations with type 2 diabetes. This computer simulation model is designed to assess the total burden of disease over an extrapolated lifetime for populations with type 2 diabetes. It uses a wide variety of input data, including knowledge of previous clinical events for individuals, and has the ability to take into account changes in some risk factor levels over time. If these updated risk factor levels are not available, the model provided methods of calculating them. OM2 outputs include estimated Life Expectancy, Quality Adjusted Life Expectancy, and costs for each member of a given population

UKPDS

People with type II diabetes have a risk of coronary heart disease up to 3 times greater than the general population⁶. The UK Prevalence of Coronary Heart Disease in persons with type II diabetes⁷.
6 Kanaya et al. Explaining the sex difference in coronary heart disease mortality among patients with type 2 diabetes
 7 Stevens et al. The UKPDS risk engine. Clinical Science 2001;101:671-679

Please enter the following information.

Age: years

Weight: kg

Height: cm

Gender: Male Female

HDL cholesterol: mmol/L

Total cholesterol: mmol/L

Systolic Blood Pressure: mmHg

Smoker: Yes No

Afro-Caribbean ethnicity? Yes No

HbA_{1c}: %

Time Period: years

Regular Exercise per week:

Effectiveness of Intervention:

Blood Pressure Lowering Therapy

Quit Smoking

Lipid Lowering Therapy

5Kg Weight Loss

Regular Exercise (3 times per week)

Results

Based on the information you provided your absolute risk score using the UKPDS model is **0.37 %**

Your Body Mass Index (BMI) is **25.2 (Healthy Weight)**

Risk Predictions

Predicted Risk
 0 - 25% 25 - 50% 50 - 75% 75 - 100%

Figure 10 UKPDS Total CV Risk Calculation

Figure 11 UKPDS Risk calculation by CV Entity (UKPDS Risk Engine)

2.1.2 Advance Risk Engine

The ADVANCE risk engine (<http://www.advanceriskengine.com/>) is a risk calculator specifically designed around people with type 2 diabetes. It was developed using data for the ADVANCE trial participants without any history of cardiovascular disease at study enrolment. The ADVANCE risk equations are based on risk factors commonly assessed in routine clinical practice. This application provides the risk of developing cardiac and kidney complications associated with diabetes. The ADVANCE risk engine provides the risk of having a cardiovascular event over 4 years and an estimate of the risk of developing major kidney events in the short term over the next 5 years, or in the longer term (starting with albuminuria). The Figure 12 shows the main page where you can either launch the Cardiovascular or Kidney Risk Engine.

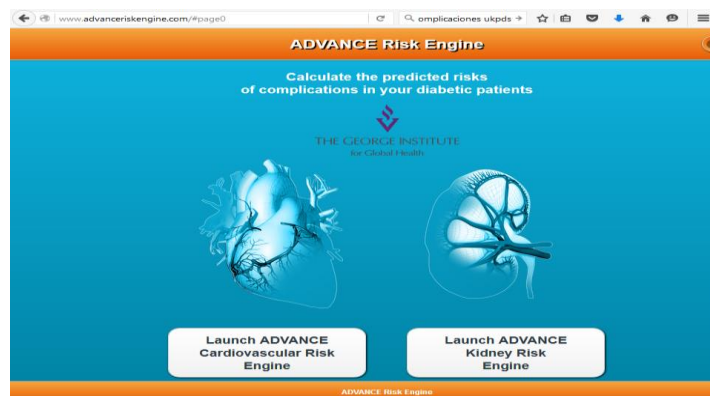


Figure 12 Advance Risk Engine- Main Menu

Figure 13 shows the view to get input from the user for risk calculation and perform the calculation or save or load the results.

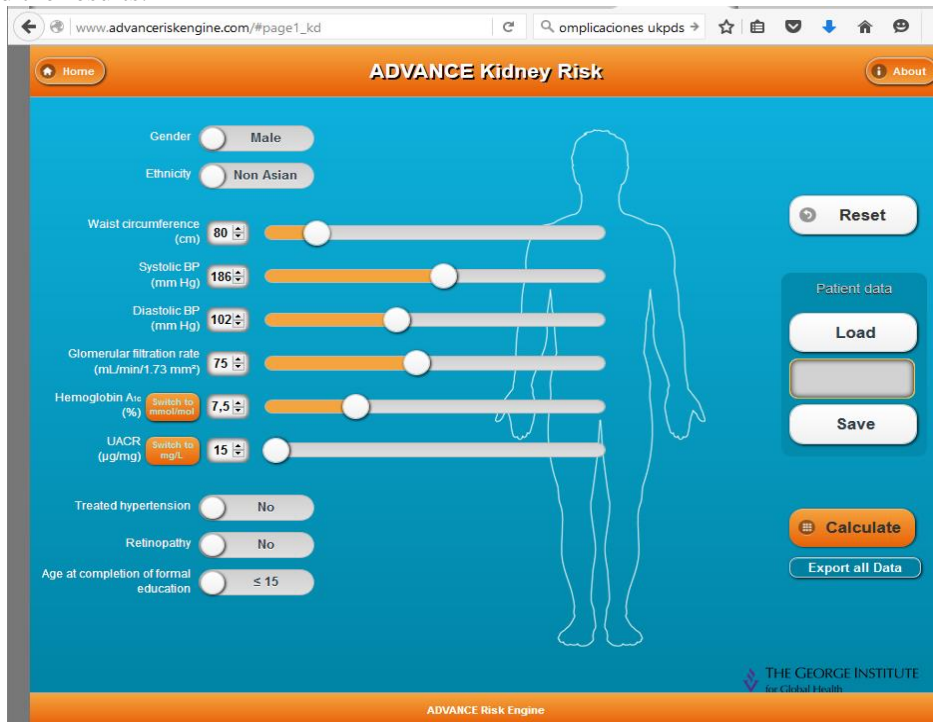


Figure 13 Advance Kidney Risk Input Provision

Figure 14 shows the how the outcome is visualized for cardiovascular risk prediction. Similarly, Figure 15 shows the visualization of the outcome for the Kidney Risk engine.

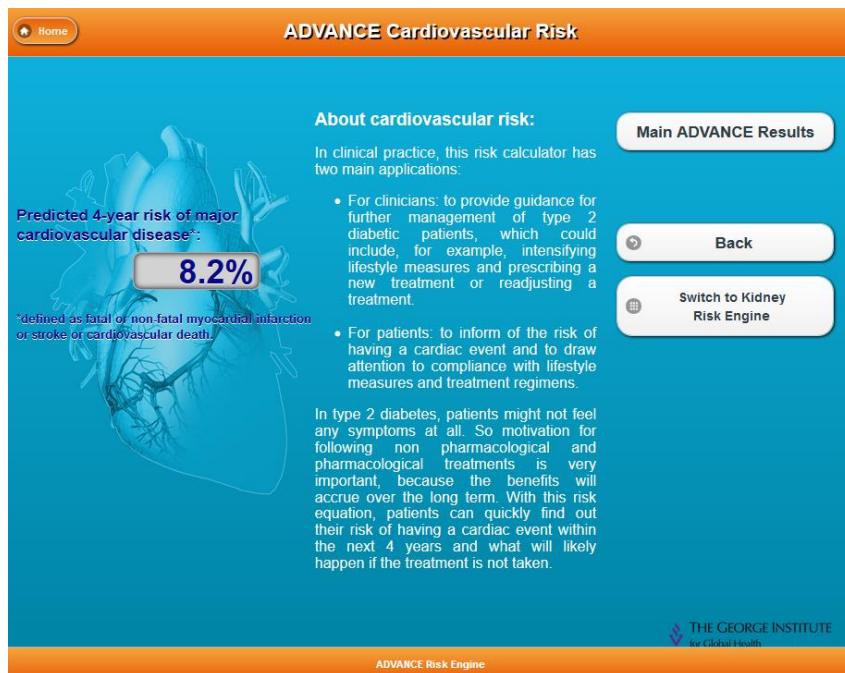


Figure 14 Advance Cardiovascular Risk Outcome Visualization

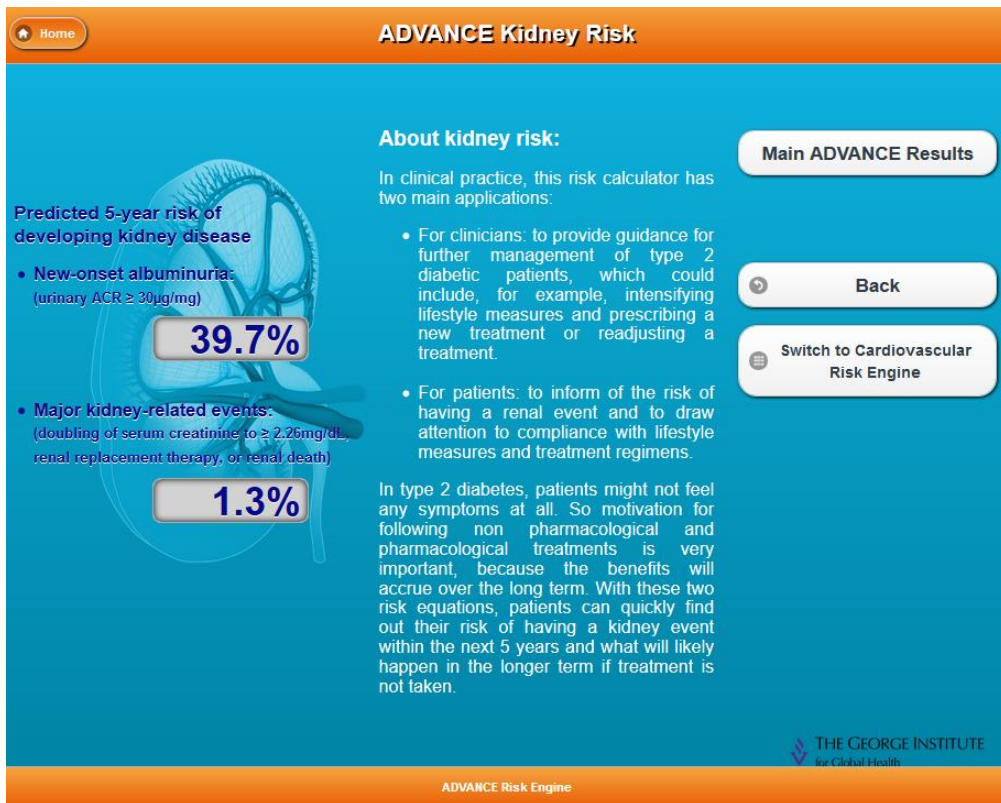


Figure 15 Advance Kidney Risk Outcome Visualization

2.1.3 QRisk2-2015

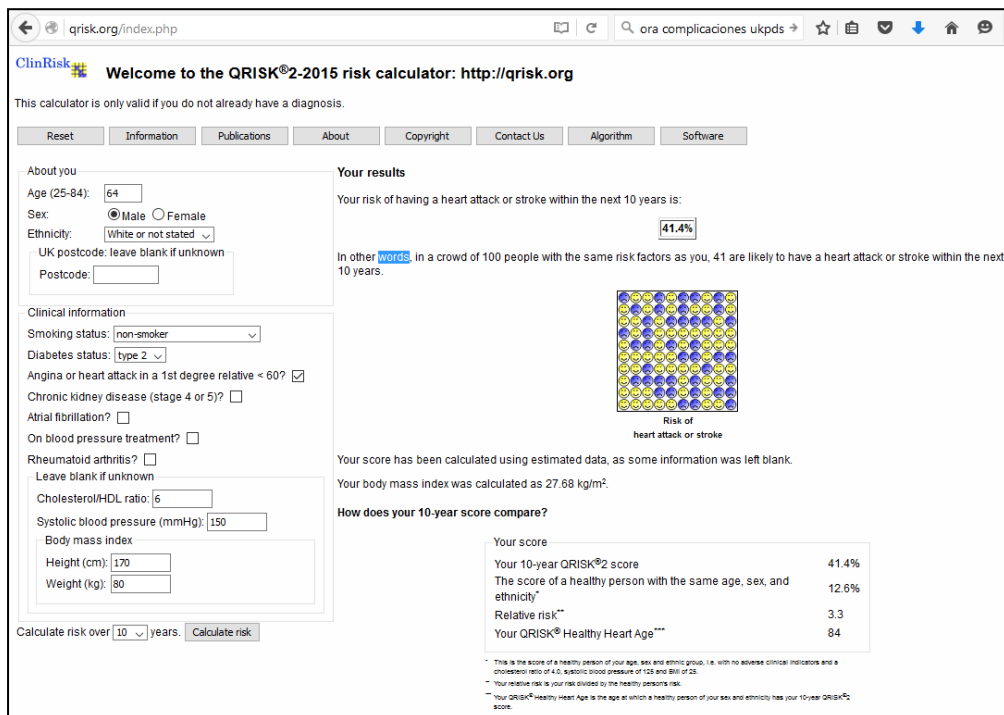


Figure 16 Visualization of QRisk2 Simulation Panel

Figure 16 shows the simulation panel for QRisk2 engine that calculates the heart attack risk. Here the difference from other risk engines is that it visualizes the comparison of calculated 10-year risk score with healthy persons with the same characteristics; by a figure and further values.

2.1.4 Framingham

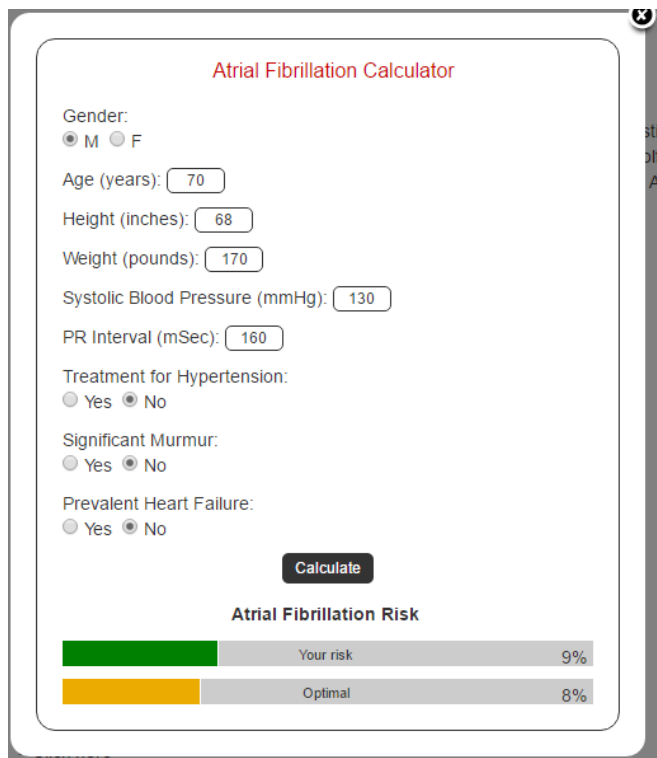


Figure 17 Framingham Risk Score Visualization

Figure 17 shows the visualization used by Framingham Risk Engine for atrial fibrillation risk calculation.

2.1.5 T1D Major Outcomes Model

Figure 18 shows the figure in the publication that introduced the T1D Major Outcomes model. The publication mentions an available tool in Excel but this cannot be accessed via the specified hyperlink in the publication.

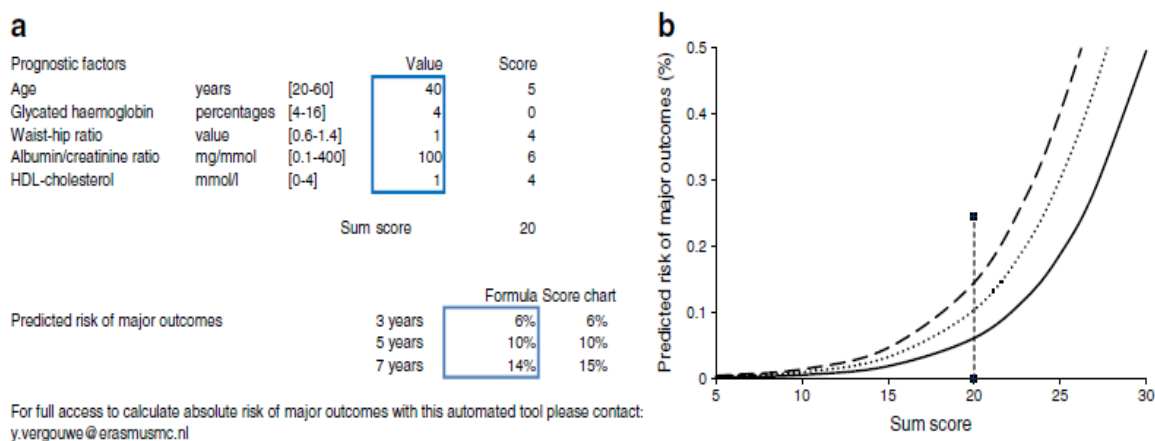


Figure 18 T1D Major Outcomes Model Display

3 POWER2DM UI Designs for Prediction/Simulation Visualization

3.1 Physician Perspective (UIs used in Shared Decision Making Phase)

3.1.1 Treatment Planning with KADIS View

This view will be the part of POWER2DM Shared Decision Making (SDM) Web Application that enables physicians to plan the medication orders and carbohydrate restrictions with the help of KADIS model through simulations. In general, as shown in Figure 19, the design of the view is very similar to the original KADIS interface used in IDK for current practice with some slight changes.

The view consists of the following panels;

Patient Profile Panel: The common panel shown as a part of every view in POWER2DM SDM application providing basic information about the patient like; gender, age, etc. See POWER2DM D1.3 for details of the panel and the designed mockup.

Blood Glucose Summary Panel: This is also one of the common models used for blood glucose related views in POWER2DM SDM showing latest HbA1c, the goal for HbA1c and QScore analysis. See POWER2DM D1.3 for details.

Simulation Graph Panel: This panel consists of three charts stacked on top of each other as in the existing user interface of KADIS where the x-axis is the time of the day. At top, blood glucose chart shows the followings;

- **KADIS Fingerprint** as a line chart (the grey one in Figure 19) which shows the latest base blood glucose profile of patient calculated from the 3-day period CGM or fingerpick blood glucose measurements.
- **Baseline CGM** as points in the chart (scatter chart) showing the CGM measurements collected for KADIS Fingerprint identification in the 3-day period. If the fingerpick measurements are used in this process, then they will be shown instead. The chart shows the measurements for each day in a separate colour (e.g. tones of grey in the figure).
- **Estimated Blood Glucose Profile** shows the estimated blood glucose profile if the patient adheres to the treatment plan specified in the Current Treatment Plan panel. In other words, this is the result of the KADIS simulation. This simulation is expected to be done for each change in the treatment plan so there is no another button to simulate.
- **Blood Glucose Measurements (Hourly box plot)** shows the blood glucose measurements of patient in the last self-management period by grouping the measurements into the hours and showing them as box plot chart. See Section 3.1.2 for details of this chart.

The green area shown the normal range for blood glucose and the red line shows the hypoglycaemia limit. In the right, there is a filter panel and physician can select which charts he/she wants to see in the graph.

In the middle, the insulin/medication chart shows the planned insulin injections and medication intakes. Insulin orders are shown as column chart where the y-axis shows the amount of insulin. As in KADIS original interface, **basal and bolus insulins** will be shown in separate colours.

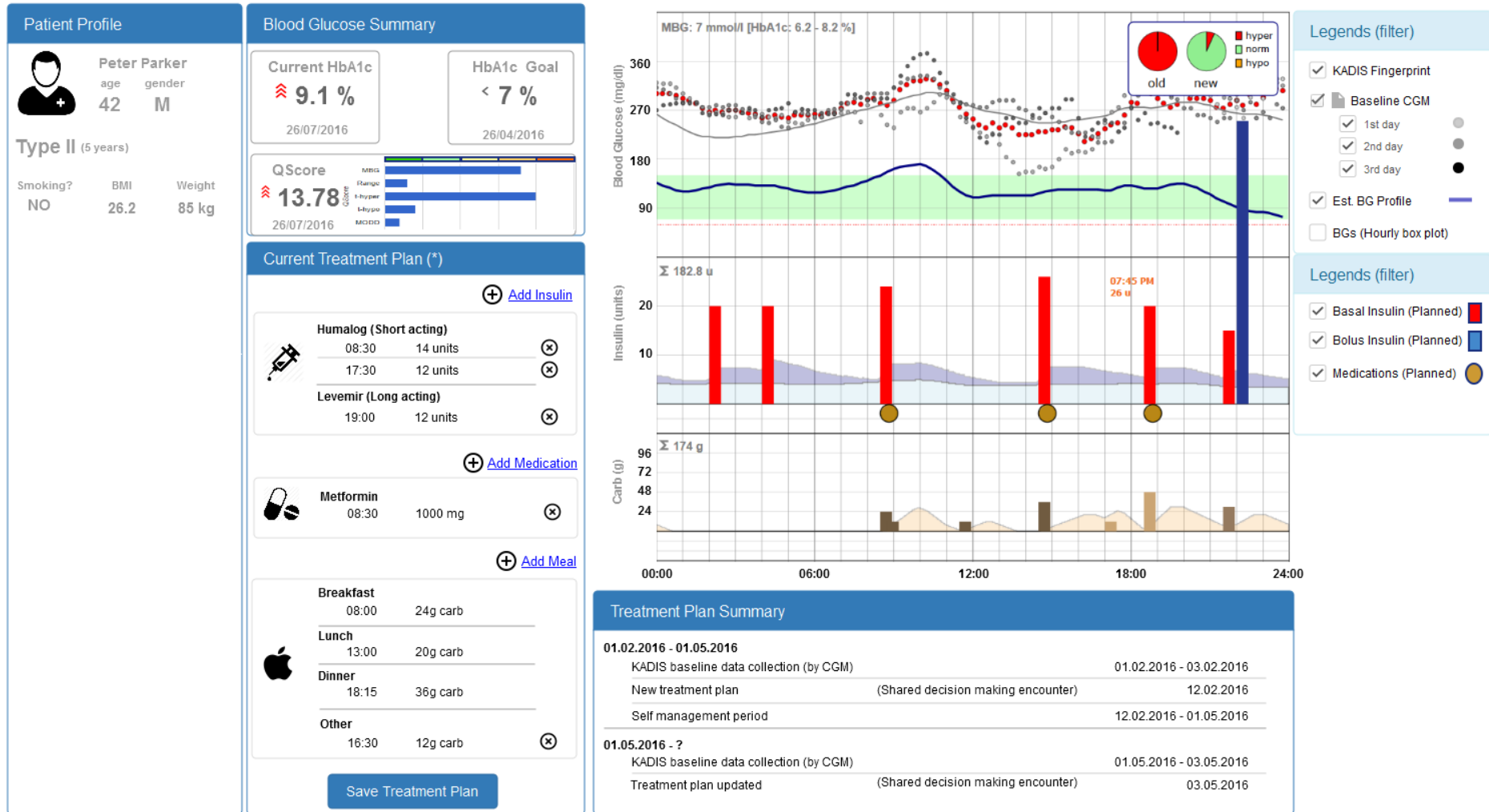


Figure 19 Treatment Planning with KADIS View

The **medication intake** plan is shown by circles below the insulin plan graph.

The below chart shows the **carbohydrate intake plan** for the patient where the y-panel is carbohydrate amount in grams.

Current Treatment Panel: This panel shows the details of planned treatment. In the insulin part, it shows the name of insulin (e.g. Humalog), type of insulin (e.g. Short-acting), times and dosage for injection. Clicking “Add Insulin” will open a popup where the user can add another insulin injection item to the list. Similarly, the medication name, time and dosage is shown in medication part. For the dietary part, the meal (e.g. breakfast), the suggested time and carbohydrate amount for that meal is shown. The user should click “Save Treatment Plan” button if he wants to save the plan for the patient.

Treatment Plan Summary Panel: This panel shows the history of the changes in plan and KADIS Fingerprint identifications.

3.1.2 KADIS Planned Blood Glucose Profile vs Actual/Estimated BG Measurements

In order to support physicians to understand the blood glucose management performance of patient, a summary chart is designed. This chart can be used as a part of several views of POWER2DM SDM application.

The Figure 20 shows a version of chart showing a comparison between

- the Blood Glucose Profile predicted by KADIS based on the last treatment plan suggested for patient (the blue line)
- and the actual blood glucose measurements done in self-management period (orange dots as box plot).

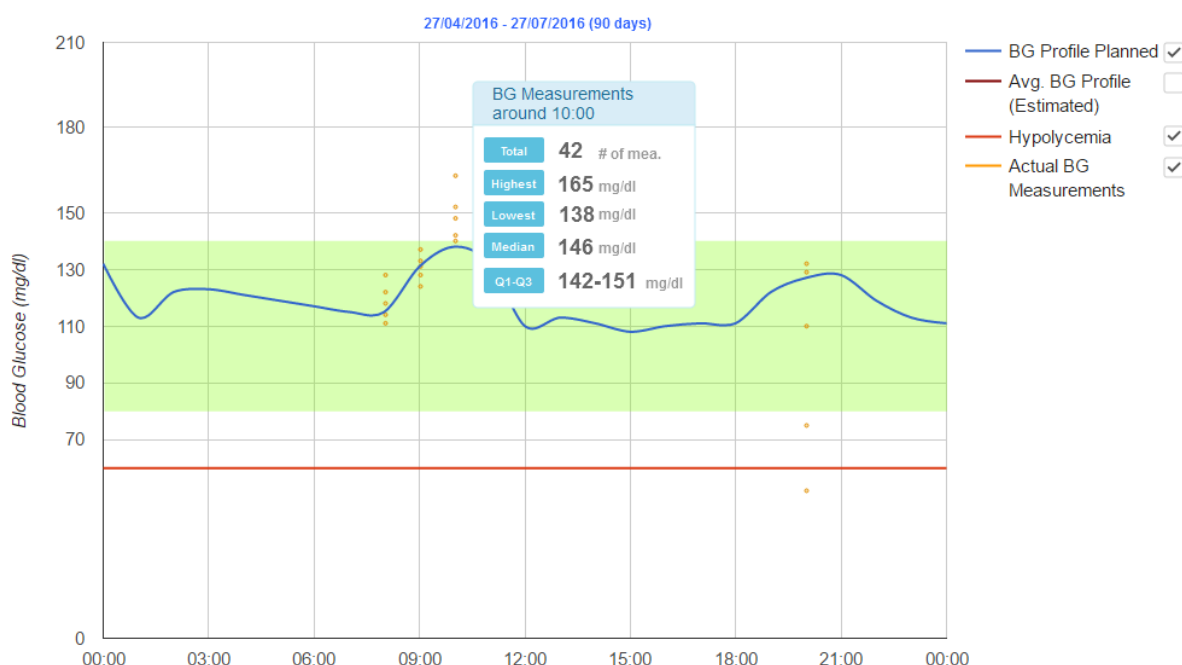


Figure 20 KADIS Estimated Blood Glucose Profile for Current Treatment Plan vs Blood Glucose Measurements Chart

The actual BG values are grouped into the hours they are measured (e.g. measurements between 9:30 to 10:29 goes to 10:00) and for each hour a box plot chart is shown by using points. As usual in box-plot charts,

- the upper point shows the highest BG value measured within that hour
- the lower point shows the lowest BG value measured within that hour
- the middle one shows the median of the measurements
- and the others shows the Q1 and Q3 values (interquartile range)

As shown in the figure, a tooltip will show the total number of measurements and the above values for that hour.

As shown in the figure, chart is configurable and user can select the chart elements to hide or show. Figure 21 shows the version where the comparison is with the average BG profile summary calculated from the KADIS estimations for each day based on the collected data; dietary intake logs, insulin medication intake logs and physical activity. The average BG profile summary is shown as area interval where

- the line in the middle shows the median of estimations for each day
- the dark interval area shows the majority area of estimations (interquartile range)
- the light interval areas show the minority area of estimations

KADIS estimations for each day will be done only for the days where enough data is available; e.g. if patient has dietary intake logs, etc. So this option may not be available for some of the patients.

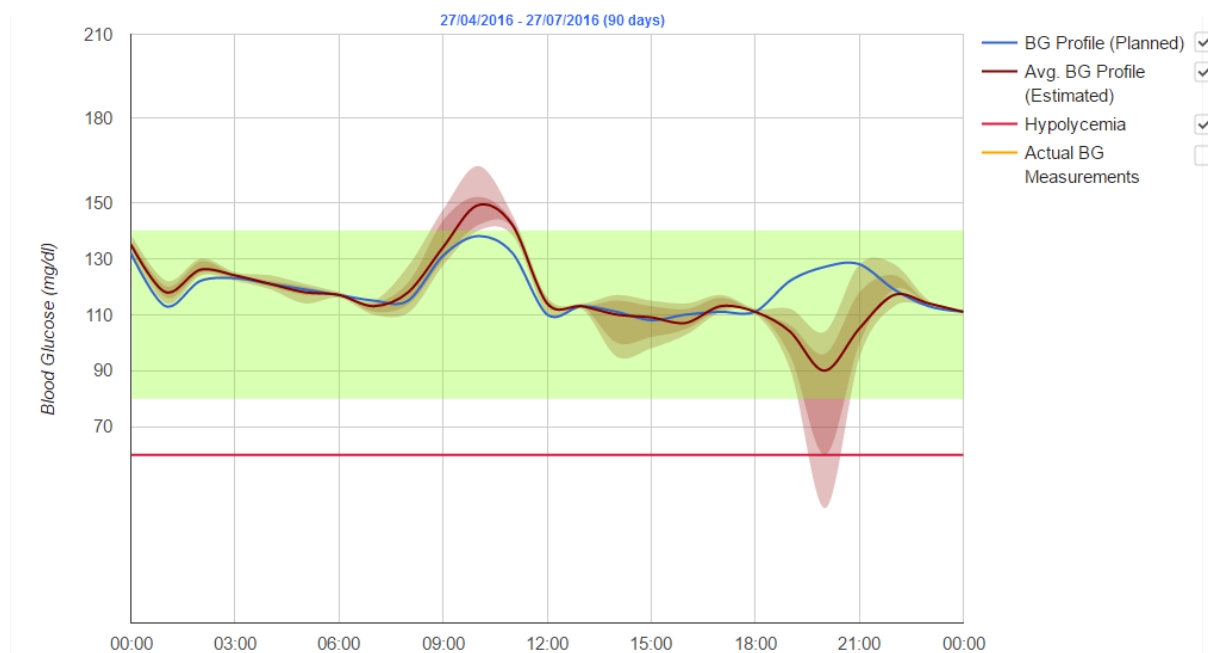


Figure 21 KADIS Estimated Blood Glucose Profile for Current Treatment Plan vs KADIS Estimations Area Interval

3.1.3 Risk Score Compass Panel

This panel will be used as a part of the main dashboard view in POWER2DM SDM Application and show the risk score calculations according to the latest available data (last self-management period) in a compass like view. As shown in Figure 22, the panels shows the risk scores/values with a color code showing the how good/bad it is. Furthermore, it is recommended by clinicians to also show the reference point for each item to see the optimal reachable value and the potential range for improvement (currently not shown in the figure).

Hovering on one of the circles will show more details regarding the calculations e.g. KADIS QScore chart for KADIS QScore. The determined compass components are as follows;

- **UKPDS CVD:** Latest CVD risk value calculated for patient
- **KADIS QScore:** KADIS QScore value calculated
- **Diabetes Trend:** A value indicating the diabetes progress based on M2TD-Marvel model predictions
- **T1D Major Outcomes:** The risk score calculated by T1D Major Outcome model
- **Score SRVO:** Score Central Retinal Vein Occlusion
- **SDCI-Foot Ulcer**
- **Advance Kidney:** The major kidney event risk score calculated by Advance Risk Engine

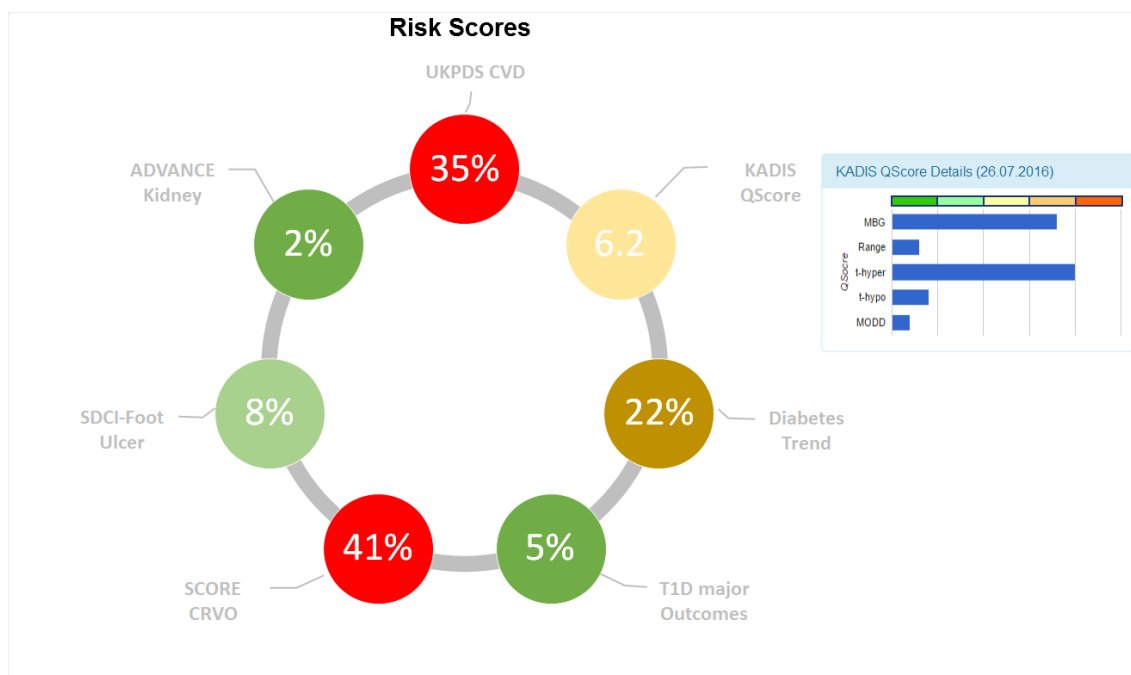


Figure 22 Risk Scores Compass Panel

3.1.4 Mid-term Predictions/Simulation Panel (MT2D-Marvel based)

See Section 3.2.3.4. The same view that will be shown to the patient can be a part of Shared Decision Making Application.

3.1.5 Risk Score Predictions/Simulation Panel

See Section 3.2.3.5. The same view that will be shown to the patient can be a part of Shared Decision Making Application.

3.2 Patient Perspective (UIs for Self-Management Phase)

3.2.1 General Issues to show predictions to Patient

When developing model prediction/simulation tools and displays for patients, issues relating to Clinical safety, Patients lack of knowledge and difficulty of understanding of mathematical concepts need to be addressed, for example:

Clinical Safety – Prevent patients from taking wrong actions based on the predictions

- Limit simulation possibilities (e.g., only a fixed percentage around the treatment scenario)

- Issue warning messages according to predefined business rules

Patient’s Lack of Knowledge on the related concepts (input parameters, target predicted parameters; e.g. Fasting Insulin,)

- Only display commonly understood variables,
- provide interactive explanations
- provide internet links to background information on concepts

Difficulty to describe related mathematical concepts like (Uncertainty, specificity, significance, ...)

- Only use familiar types of display of uncertainty. People are generally familiar with the fact that prediction uncertainty of any forecast increases with time into the future. A familiar type of display might therefore be borrowed from e.g. plumes from ensemble weather forecasts that indicate the forecasted value as well as the prediction spread (e.g. 50%) .
- Use types of display that can support decisions by patients; e.g. to interpret a scenario prediction with associated uncertainty at a given timepoint one can use a quantile dotplot with a limited number of points e.g. maximum 20, derived from the quantile function of the model prediction as proposed and tested in <http://faculty.washington.edu/jhullman/busUncertaintyVis.pdf> (see figure 21A), adding coloration of the points according to established health cutoffs. One can then compare different scenario simulations by the counted number of points in different risk categories corresponding to the health cutoffs
- Provide interactive explanations

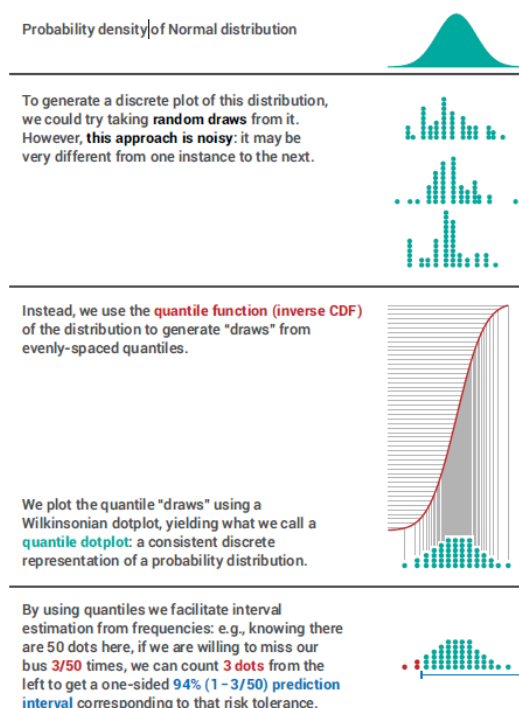


Figure 2. Explanation of quantile dotplots.

Figure 23 - Principle for generating quantile dotplots. (Figure 2 in: Kay, Matthew, et al. When (ish) is My Bus? User-centered Visualizations of Uncertainty in Everyday, Mobile Predictive Systems. In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. ACM, 2016. p. 5092-5103.)

3.2.2 POWER2DM Main Principles and Approach to these issues

The uncertainty in predictions derives from several factors:

- The quantity and quality of data (precision)
- The uncertainty coming from the model itself
- Other factors that may affect the precision

A full description of the prediction uncertainty would require to address all these factors in accessible information for the patient. This is not deemed practical for the purpose of the project. Some issues however might be addressed relatively easily in supporting information material available via interactive explanations:

- Mentioning/explaining the above factors in common language
- Describing the significance of parameters in the resulted prediction (relative importance of parameters; derived from sensitivity analysis)
- Describing the rational or evidence based studies behind the prediction model (links to relevant scientific publications on the models)
- Describing the parameters of the model (e.g. control, goal variables) (links to model descriptions available e.g. in the literature or other EU project deliverables; however preferably stated in common language)

3.2.3 Mockups for Patient Centered Visualizations of Predictions

3.2.3.1 Daily Comparison View; KADIS Estimated BG Profile with the given Treatment Plan vs Actual BG Measurements

Patient can use this view to evaluate his/her blood glucose management performance for a specific day. As shown in Figure 24, the view consists of two panels. The left panel, **Daily Blood Glucose Analysis** panel shows the comparison of what is the planned and what is in actual based on the measurements and KADIS predictions. The upper chart visualizes the following information;

- **BG Profile (Planned):** This is the predicted Blood Glucose Profile (by KADIS) if the patient follows the specified treatment plan (carb intake, insulin and medication instructions) in the last visit. Shown as blue line.
- **BG Profile (Estimated):** This is the predicted Blood Glucose Profile (by KADIS) based on the ODL collected from the patient for this day; dietary intake logs, medication/insulin administration logs, exercise logs. It is shown as dark blue line. If not enough data is collected (no dietary intake logs) to perform the prediction than this line will not be shown.
- **BG Measurements:** Shows the blood glucose measurements over the chart by dots which enables patient to compare what is planned in compare to actual measurement.

The middle chart shows the comparison of what is planned in terms of medication and what patient actually does. As in the original KADIS interface, the basal and bolus insulins are shown separately. The followings will be shown in the chart;

- **Basal Insulin (Planned):** Shows the time and dosage of the planned basal insulins as column chart.
- **Bolus Insulin (Planned):** Shows the time and dosage of the planned bolus insulins as column chart.
- **Basal Insulin (Actual):** Shows the time and dosage of the basal insulin intake as column chart if it is logged by patient. (Figure does not show this as it is not logged by patient in this example)
- **Bolus Insulin (Actual):** Shows the time and dosage of the bolus insulin intake as column chart if it is logged by patient.

Similarly, the lower chart shows the comparison of what is planned in terms of carbohydrate intake what patient actually does. The following information will be shown;

- **Carb Intake (Planned):** Shows the planned meals; timing and carbohydrate restrictions.
- **Carb Intake (Actual):** Shows the actual carb intakes (timing and amount) that is extracted from the Dietary Intake Logs of patient (e.g. from FatSecret logs).

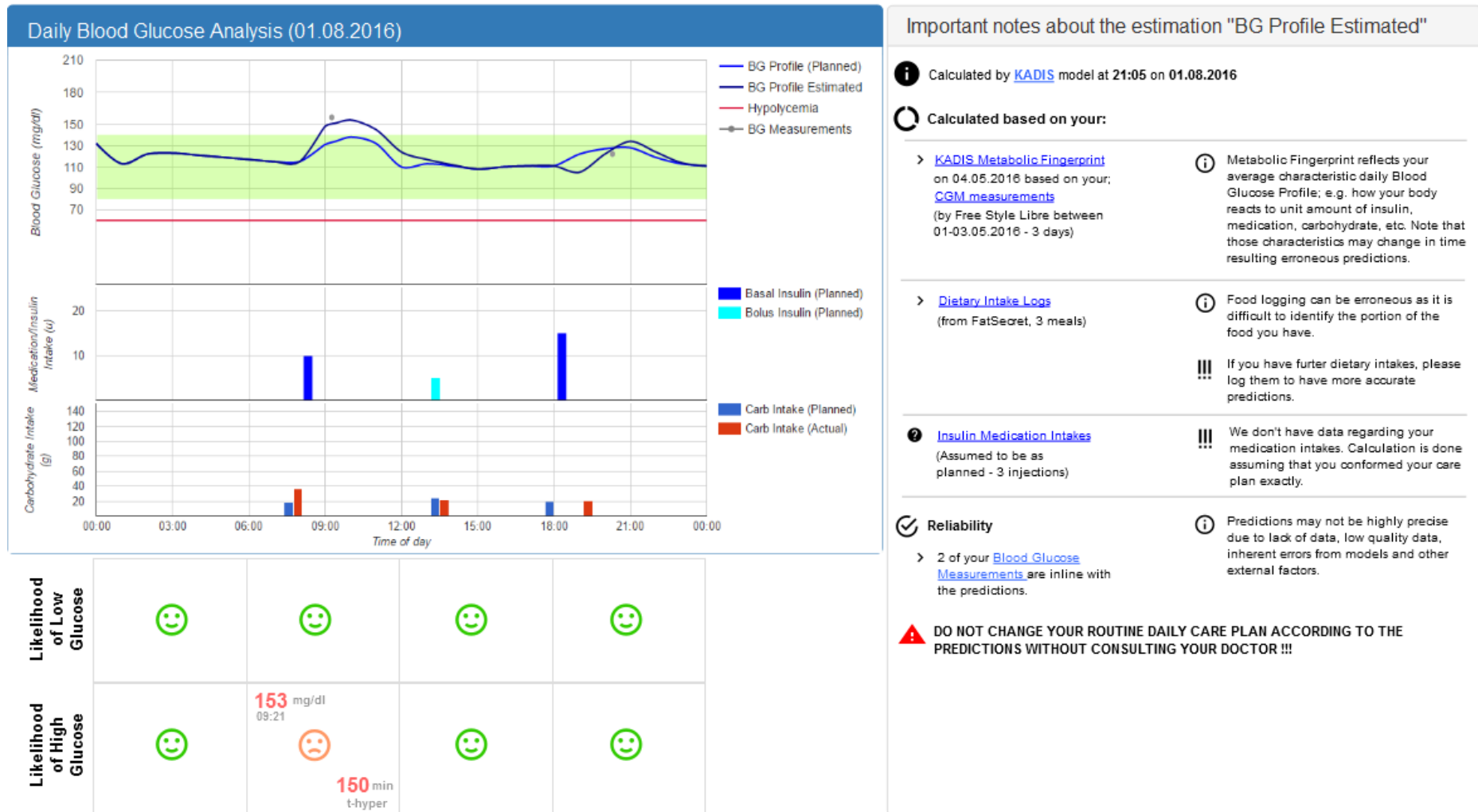


Figure 24 Daily Blood Glucose Performance Analysis

The panel below these charts will show the either actual situation or prediction in terms of two category Low Glucose and High Glucose. The evaluations are done for 6-hour intervals and based on the actual measurements and the predictions, the evaluation is shown by a happy face or sad face with color showing how good or bad it is. For problematic parts, the highest/lowest measurement and the predicted t-hyper (total duration of high glucose) or t-hypo (total duration of low glucose) can be shown.

The other main panel, “Prediction Notes” panel (light blue header in Figure 24), provide information to user about the predictions done regarding blood glucose profile and shown in the charts. By clicking on the legends of the chart, the corresponding notes will be shown. In the figure, it is assumed that user has clicked the “BG Profile (Estimated)”. The panel show the following information;

- The model used for the prediction (KADIS in this example) and the time the prediction is performed. By clicking on the model name, patient can get further information about the model and prediction methodology.
- The data used for the KADIS prediction as input;
 - KADIS Metabolic Fingerprint, when it is created, which data it is based on and when and how the data is collected. Patient may click on the hyperlinks to see the details of the baseline data and the constructed fingerprint
 - Dietary Intake logs the prediction is based on, from where it is collected, and the number of logs
 - Insulin/Medication Intake data the prediction is based on. As you see from the figure, patient is notified that the prediction is done based on the assumption of patient complying with the medication/insulin plan
- On the right, the notes and warnings are shown regarding the prediction and how the data is used. For example, for dietary intake;
 - Patient is informed that food logging can be erroneous
 - Patient is warned to log further dietary intakes if exist to get more accurate predictions
- Information about the reliability of prediction. In this example, we inform patient that his blood glucose measurements are in line with prediction and information about the reason the prediction may not be accurate. A numerical value indicating the accuracy/or error interval can be provided.
- Major warning that warn patient not to change his current treatment plan (like injecting more insulin, etc) based on the predictions.



Figure 25 Blood Glucose Management Performance Summary

3.2.3.2 Summary BG View: KADIS Estimated BG Profile with the given Treatment Plan vs Actual BG Measurements

Patient can use this view to analyse his blood glucose management performance over a period (e.g. a month, 3 months). As shown in Figure 25, the view consists of two main part. The “Blood Glucose Performance Summary” panel shows the comparison of what is planned and how patient performs based on the actual blood glucose measurements and KADIS blood glucose profile predictions based on ODL collected from patient; dietary intake logs, medication/insulin intake logs, exercise logs. The view is very similar to the view described in Section 3.2.3.1. The only difference is the logic of charts.

The upper chart shows the following information;

- **BG Profile (Planned):** This is the predicted Blood Glucose Profile (by KADIS) if the patient follows the specified treatment plan (carb intake, insulin and medication instructions) in the last visit. Shown as blue line.
- **Average BG Profile (Estimated):** (Not shown in the figure) This will be line interval chart which will be constructed from the KADIS Blood Glucose Profile predictions for each day based on the ODL collected in that day (dietary intake logs, medication/insulin intakes). The line will show the average of all predictions, while the intervals show the Q1-Q3 values (with dark green color) and upper and lower values (with light green color). If not enough data is collected for a specific day, the prediction will not be done and not considered for the construction of chart.
- **Actual BG Measurements:** Shows the actual measurements as line interval chart as shown in the figure (the brown areas). The dark part shows the Q1-Q3 interval (most of the measurements) and light part shows the extent of the highest and lowest measurements.

In the right panel, this time the figure shows the notes for “BG Profile(Planned)”. The design is similar and the idea is to provide information about the prediction.

3.2.3.3 Diabetic Health Progress Indicators View

Patient use this view to monitor the important parameters that effect the progress of diabetes. Mainly the view is related with the M2TD-Marvel prediction model that predicts the progress of several parameters like BMI, Fasting Insulin, etc. in middle term (1 month to 6 years) based on the lifestyle performance of patient. The Figure 26, Figure 27, and Figure 28 shows panels that will be part of this view.

In the left side of the view, the **Lifestyle Performance panel** (Figure 26) will be located. This panel will show the latest performance of patient for several parameters that are used as input to the M2TD-Marvel model. For each parameter, a column chart is shown where the performance is shown as monthly basis for the last months including the last two physician visits. The y-axis of graphs shows the value-range for the parameter and the colours shown between the ranges show how bad or good the performance is. In each column, graphs show both the **goal set for that parameter** (e.g. Goal for average physical activity per day) for that period (the light box) and the **actual performance** calculated from the data collected for that month.

The panel will show the following parameters;

- **Average Physical Activity per day (min/day):** This is the average moderately active minutes of patient per day. It will be calculated based on the activity tracker device logs.
- **Average Calorie Intake per day (cal/day):** Average calorie intake of patient per day calculated from the dietary intake logs of patient.
- **Average Food Quality**

- The exact items to show still need to be decided upon. Currently, it is anticipated that **Carbohydrate intake (g/day), fibre intake (g/day) and fat intake (g/day and %saturated/total fat)** will be included.
- **Sleep/Stress Relaxation:** The exact items to show still need to be decided upon. Currently, it is anticipated that indicators of **sleep quality** and of **calmness/focus/ tenseness** derived from personal devices (Fitbit and Spire, resp.) will be displayed
- **Insulin/medication use:** The exact items to show still need to be decided upon. Currently it is anticipated to show a measure of **Compliance with the treatment plan.**

Next to this panel, the **Diabetes Health Progress Indicators panel** will be located. This panel shows the main parameters that affect the diabetes progress. In general, these are the target parameters predicted by M2TD-Marvel model. For each parameter, a graph will be shown as indicated in Figure 27. On the left of the graph, icons indicate which Lifestyle Performance parameters influence the progress of the indicator. For example, Avg. Physical Activity and Avg. Calorie Intake performance affects the Body Mass Index according to the MT2D-MARVEL model and this is shown in the graph.

The graph shows the following information (based on the example shown in Figure, other parameters will have same logic);

- **BMI:** The actual measurements for each month including the last two physician visits until current time. The y-axis shows the scale of the value and the color between the scales show how good or bad the value is.
- **BMI (Target):** This is the MT2D-Marvel prediction for next two physician visits assuming that patient can reach the goals set for the related lifestyle parameters.
- **BMI (Estimations before POWER2DM):** This is the MT2D-Marvel prediction done at the beginning based on the baseline performance of patient.
- **BMI (Estimations with the latest performance):** This is the MT2D-Marvel prediction for next two physician visits assuming that patient continue his performance in the last self-management period.

The graph also shows the 1, 3 and 6 year predictions.

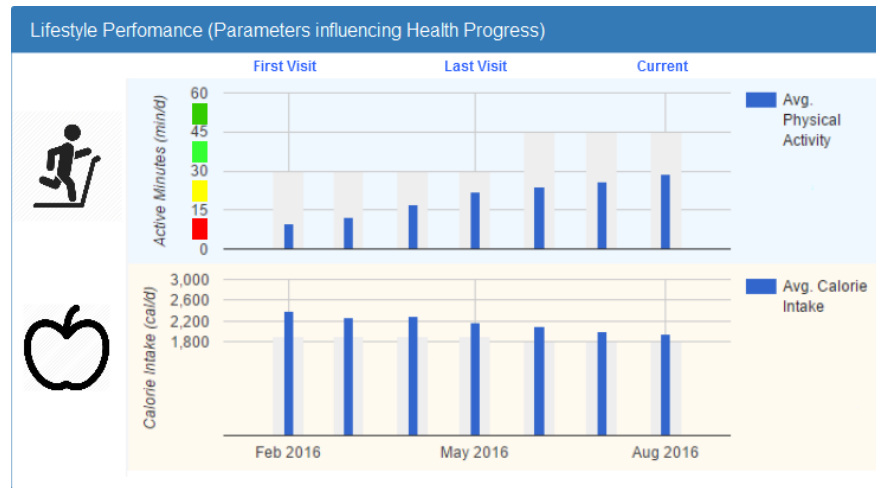


Figure 26 Lifestyle Performance (Parameters Influencing Health Progress – MT2D-MARVEL Input parameters)

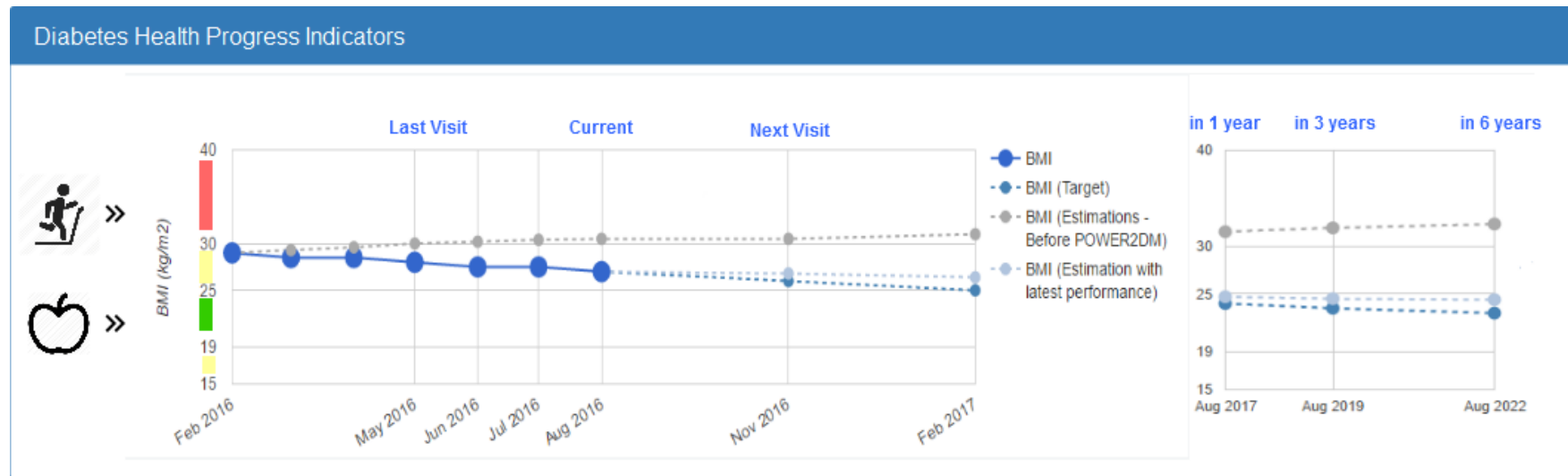


Figure 27 Diabetes Health Progress Indicators (related with MT2D-MARVEL)

Important Notes about Health Progress Predictions

- ● - **BMI (Target)** shows predictions of BMI progress if you **reach your goals** for the next periods.
 - i Prediction is done by [M2TD-MARVEL](#) model on [10.08.2016](#)
 - C Calculated based on;
 - > [Goal \(Average Daily Physical Activity\)](#)
(set on 10.08.2016)
 - > [Goal \(Average Daily Calorie Intake\)](#)
(set on 10.08.2016)
- ● - **BMI (Estimations - Before POWER2DM)** shows predictions of BMI progress if you would have continued your **previous lifestyle before starting POWER2DM care program**.
 - i Prediction was done by [M2TD-MARVEL](#) model on [01.02.2016](#)
 - C Calculated based on;
 - > [Physical Activity Logs](#)
(between 24-31 January 2016 from Fitbit HR)
 - > [Dietary Intake Logs](#)
(between 24-31 January 2016 from Fatsecret)
 - !!! Prediction is done only based on your average lifestyle for one week.

Figure 28 Notes Panel for Health Progress Predictions

The last panel, as shown in Figure 28, shows the notes about the predictions. It describes what each information item shows, the model used for prediction, the date of calculation, the information used for the prediction calculations and warnings related with these predictions.

Currently, no final decision has been made on which other variables to show. It is anticipated that **Fasting glucose** will be included. Possibly, HbA1c predictions can be derived from the glucose prediction and shown instead. Medical-technical variables such as **Insulin sensitivity** and **Beta cell function** will most likely have little meaning for the patient, therefore it is currently considered to instead display items associated with these predictions that have a clear

impact on the patient's daily life. Examples would be the start of medication, the start of insulin use, the start of kidney dialysis etc.. This is still matter of discussion.

3.2.3.4 Diabetic Health Progress Indicators Compass

Similar to the Risk Scores Compass panel (Figure 22), MT2D-Marvel predictions may be summarized in a compass view as in Figure 29, with the small panels showing timecourses that are essentially miniature versions of Figure 27. The parameters shown may be replaced by alternative ones that are more meaningful to the patient as discussed in the previous section. In the center of the compass, the top-3 most effective interventions (as derived from model sensitivity analysis) may be indicated (not shown in Figure 29).

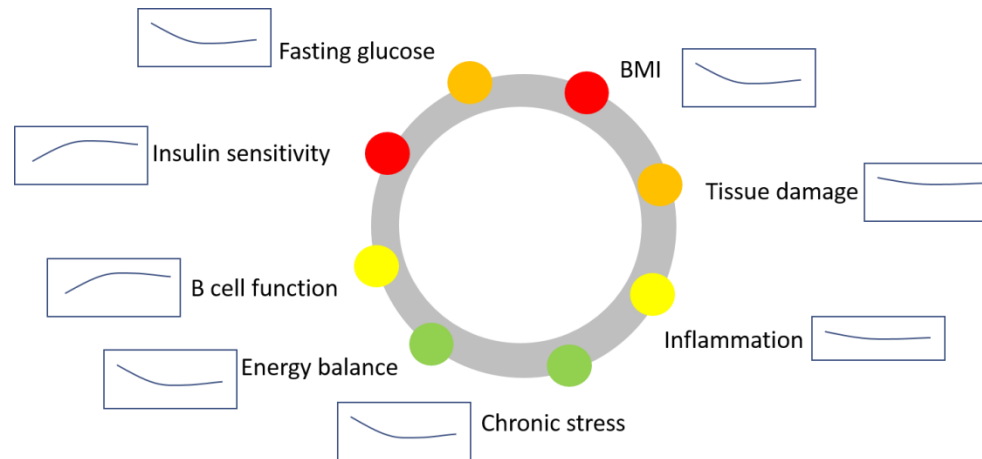


Figure 29 Health Progress Compass

As a tool to help in lifestyle choices, the display in Figure 30 may be used, possibly combined with information of the variables that are most affected by each parameter.

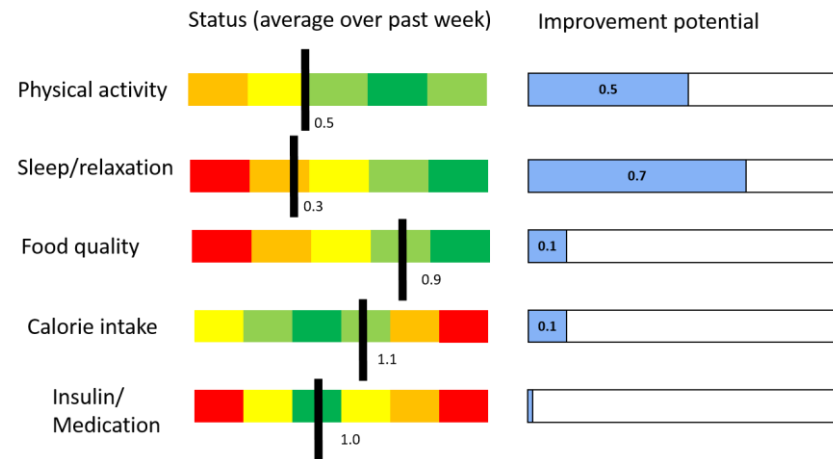


Figure 30 Lifestyle Performance Feedback

3.2.3.5 Major Outcomes and Risks Panel

Patients can use this view to analyse personalized long term risks calculated for them regarding diabetic complications like cardiovascular diseases, kidney problems, major outcomes of Type 1 diabetes, etc. Some parts of the view are illustrated in Figure 31. The left panel, **Influencing Parameters panel**, show all the input parameters that has an influence on these risks. In other words, they are the input parameters for the risk models used in POWER2DM. However, in this panel, only the ones that may be improved by health behaviour change or clinical interventions are listed. The panel shows the following information for each parameter in a table like view;

- **Current:** Shows the latest value of the parameter (e.g. latest HbA1c, latest smoking situation). If there is no information logged in Personal Data Store regarding the parameter in the last specified period (e.g. last month) then this will be indicated. The date of measurement or information entry is also shown below the value. Clicking on the value show the details of measurement or record.
- **Goal:** This value shows the goal set related with that parameter if exist. For example, in figure, the HbA1c goal is set to 6.9%.
- **Previous:** This value shows the previous value of the parameter for patient at the start of POWER2DM care program.
- **Optimum:** This is the optimum value expected for a diabetic person with similar characteristics (age, gender, ethnicity, etc).

For each parameter, the parameter name and an icon indicating the parameter leads the table row. Next to them, there is an information icon and if clicked more information is shown to patient regarding the parameter.

The **Other Parameters panel** also lists the input parameters for the used risk models but this time only the ones that cannot be manipulated like age, gender, duration of diabetes, ethnicity, etc.

On the right of the view, there will be a panel for each risk calculation for a group of complications;

- Cardiovascular Risks
- Kidney Risks
- T1D Major Outcomes

Figure 31 shows an example for UKPDS Risk Engine outputs for Cardiovascular Risks. The icons on the left of the panel shows all the input parameters used by the UKPDS Risk Engine to show patient that what parameters influence the calculated risks. Then for each cardiovascular event that UKPDS calculated the risk (CHD, Fatal CHD, Stroke, Fatal Stroke), a column chart is shown. In these column charts the following predictions are shown;

- The risk for the specified event **with the current lifestyle performance** (The values of parameters listed under “Current”). If there is no information for a parameter, the prediction is not done and this part will be empty.
- The risk for the specified event **if patient reaches the set goals** (The values of parameters listed under “Goal”). If there is no goal set for any input parameter, the prediction will not be done and this part is empty. If there is at least one goal, then the prediction is done by using the set goals for the parameters and with the current values for those parameters not having a set goal (e.g. In the figure, the only difference with the first prediction is HbA1c; if patient can reach HbA1c goal of 6.9% what will be his cardiovascular risks).
- The risk for the specified event if patient had continued his lifestyle **performance before starting POWER2DM care program** (The initial values of parameters listed under “Previous”). All the input parameters should exist for the calculation.
- The risk for the specified event calculated for **optimum values** with the same characteristics with patient (Other parameters).

The **Prediction Notes panel** shows important notes about risk score predictions. It shows

- the risk score model used for predictions
- description for each prediction and time of the calculation. For each prediction item;
 - data it is based on
 - warnings for patient regarding the prediction (e.g. If data is not available for current values, warn patient that prediction cannot be done if he not supplies the data)
 - reliability of prediction



Figure 31 Major Outcomes and Risk Score View

