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

Deliverable 6.4

D6.3.1 Small-Scale Evaluation Reports

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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)	

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EXECUTIVE SUMMARY

This Deliverable describes the evaluation of the Quantification Campaign dataset for predictive value of the KADIS model, and to assess user experiences. Due to severe incompleteness of the dataset, KADIS model evaluations were not feasible. User experiences were reported earlier in D6.2 “D6.2.1 Description of the Quantification Campaign Dataset”. Data analysis of mHealth devices Spire and Fitbit did not produce results. Data analysis of the continuous glucose measurements performed using the Freestyle Libre Flash Glucose Monitoring devices showed benefits of intensive monitoring of lifestyle parameters, differentially for type-1 and type-2 diabetes patients. In addition, the Quantification Campaign data on HbA1c levels were used to refine the power calculations for defining the size of the POWER2DM Evaluation Campaign. As a result, only 230 participants were required as compared to the 280 originally planned in the DoA.

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	iHealthLabs Europe	France

OPEN ISSUES

No:	Date	Issue	Resolved
1	Jan 31th, 2019	Complete 3-day KADIS baseline data registrations not obvious in combined dataset. Manual search through accumulated data needs to be performed	
2	Jan 31th, 2019	mHealth data from Spire and Fitbit devices not exhaustively analyzed	

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1 INTRODUCTION

1.1 Purpose and Scope

This document describes the evaluation of the Quantification Campaign for: a) predictive value of the KADIS model using 72h CGM data vs. mHealth devices and other monitoring sources; b) pilot data and interviews to assess user experiences. The QC is described in detail in D6.2. Briefly, it was an observational cohort study of three months of involvement from each participant. In this three month period there were two periods of continuous data collection (Spire, Fitbit and FreeStyleLibre (FSL) devices): an initial four week active period (Phase 1), a six week down period with no data collection, and a follow-up two week active period (Phase 2). During the two active periods, the patients were asked to continuously gather the data required by the KADIS model as described above by logging meals, medication use, fingerprick glucose measurements, and insulin injections. User experiences were gathered directly using questionnaires, and indirectly by assessing the quality of the data obtained. Clincal lab measurements were also performed.

1.2 References to POWER2DM Documents

- POWER2DM Description of Work (Proposal)
- POWER2DM D5.4 “D5.3.1 Feasibility Studies Outcome”
- POWER2DM D6.2 “D6.2.1 Description of the Quantification Campaign Dataset”
- POWER2DM Deliverable 7.2 “D7.1.2a Report on Dissemination Activities I”

1.3 Definitions, Abbreviations and Acronyms

Table 1 List of Abbreviations and Acronyms

Abbreviation/ Acronym	DEFINITION
EC	POWER2DM Evaluation Campaign
FSL	Abbott Freestyle Libre flash glucose measurement device
QC	POWER2DM Quantification Campaign

2 PREDICTIVE VALUE OF THE KADIS MODEL

In order to validate the existing KADIS model, metabolic fingerprints were to generated based on 72hr continuous blood glucose readings from the Quantification Campaign (QC). Using these fingerprints, it was to be assessed to what extent the model output is able to correctly predict actual continuous monitoring blood glucose levels over a period of one month in order to asses glycemic control. Furthermore, the stability of the KADIS model-derived fingerprint was to be assessed by comparing KADIS fingerprints from Phase 1 with those obtained from Phase 2 of the study. In addition the goal was to assess to what extent data from POWER2DM mHealth devices combined with other monitoring data sources can be used to predict continuous monitoring blood glucose levels, and improve or refine the KADIS model predictions. The following section 2.1 reports on the evaluation of the KADIS model, while section 2.2 reports on the evaluation of data from mHealth devices and clinical lab measurements.

2.1 KADIS model evaluation

As reported earlier in D6.2, collection of baseline data for KADIS, i.e. logging meals, medication use, fingerprick glucose measurements, and insulin injections met with severe difficulties. This led to data logged partially via mHealth, and partially via backup paper registrations. Collecting all this data and manually combining it into the uniform format suitable for driving the KADIS model, took considerable more labour and time than expected. Only after completion of the integrated dataset (Nov 2018) it became possible to fully assess the data quality. Upon inspection it then appeared that virtually none of the subjects had produced a complete data log that fitted the requirements for KADIS (complete log of carbohydrate intake, medication use and insulin injections over 3 consecutive days). Currently, we are investigating possibilities to reconstruct non-consecutive 3-day periods from the data e.g. by manually checking whether complete logs for any 3 days are available, which then could be rearranged to form 3-day periods with complete data logs. Though not optimal, KADIS could generate a fingerprint prediction form such data. Progress on this work at present is minimal because full priority has to be given to the Evaluation Campaign (EC) which is currently ongoing. Therefore, no results on the KADIS model evaluation are available from the QC to date.

2.2 Clinical lab and mHealth data evaluation

2.2.1 Clinical lab data evaluation

Clinical lab data showed interesting result only for glycemic control parameter HbA1c. The result is shown in Figure 2.2.1. The variability in HbA1c observed was lower than expected in the DoA. An updated power calculation for the EC study sample size indicated that 230 patients would be sufficient as compared to 280 assumed in the DoA. As a consequence, the EC study protocol was adapted.

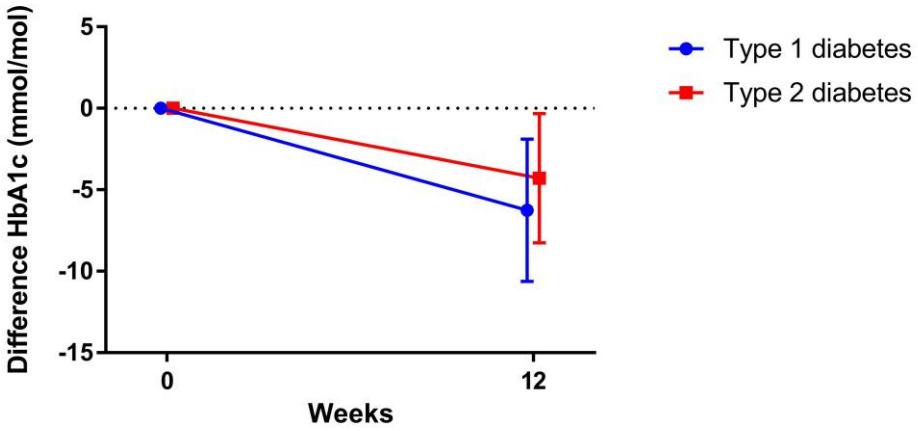

Figure 2.2.1. HbA1c improvement in both type 1 and type 2 diabetes patients observed in the QC.

2.2.2 mHealth data evaluation

Figure 2.2.2. shows an example mHealth dataset for one specific patient on a specific day.

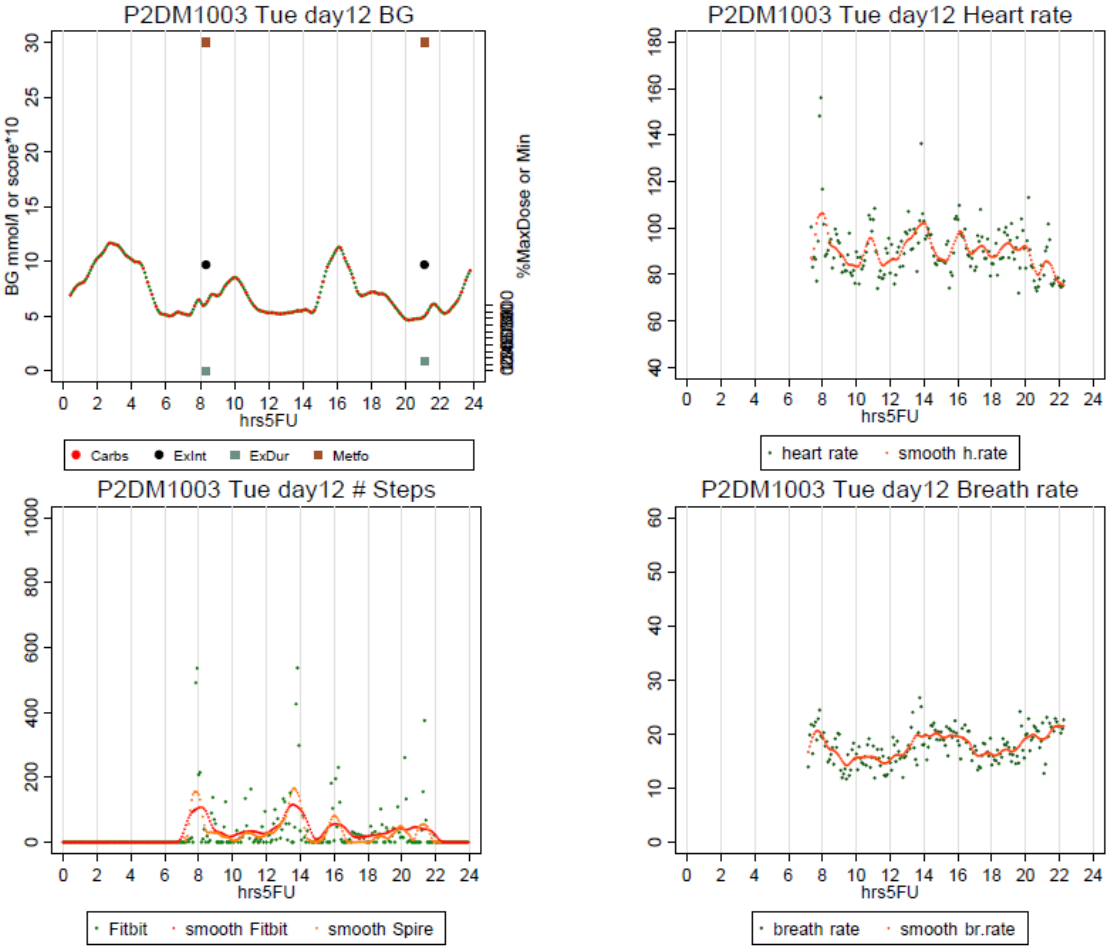

Figure 2.2.2. Example mHealth dataset for one specific patient on a specific day. The wide variability of data in successive 5-min intervals of Spire and Fitbit 9#steps and heart rate) can be well appreciated. In the BG (blood glucose) panel, the logs of meals and medication are included. This particular patient failed to log carbohydrate intake, and so serves as example for the overall deficient baseline data for KADIS model analysis.

The blood glucose registration by FreestyleLibre (FSL) Flash Glucose Monitoring went well and was much appreciated by patients. Intraday as well as intra- and interindividual data variability was high. Therefore, for data analysis it was decided to use daily averages of the FSL data.

As previously reported in D6.2, the Spire device for registration of breathing patterns (possibly indicating stress) met with considerable usability issues. Spire data registration was largely incomplete as a consequence. Data showed wide variation between successive 5-min intervals.

Fitbit data on heart rate and physical activity also showed significant gaps in monitoring, of widely varying severity for the different patients. Similar to Spire, wide variation between successive 5-min intervals were observed. Due to the strong variability, it was decided to use smoothened curves for further analysis.

The variation in data registration quality did not allow for a straightforward analysis of the mHealth data (e.g. for finding correlations with, and possibly allowing for prediction of, FSL glucose data). Instead, a custom approach has to be worked out to properly deal especially with the missing data. Since the assembling of the integrated dataset could only be completed in Nov 2018, to data no further progress on analysis of the Spire and Fitbit data can be reported. As with KADIS, progress on this work at present is minimal because full priority has to be given to the Evaluation Campaign (EC) which is currently ongoing.

In positive contrast, analysis of the daily averages of the FSL data was well feasible and yielded some interesting results as described below which were presented at several conferences (see D7.2).

There was a significant decrease in mean glucose for type-2 diabetes patients during Phase 1 of the QC. This improvement was not seen in type-1 diabetes patients (Figure 2.2.3).

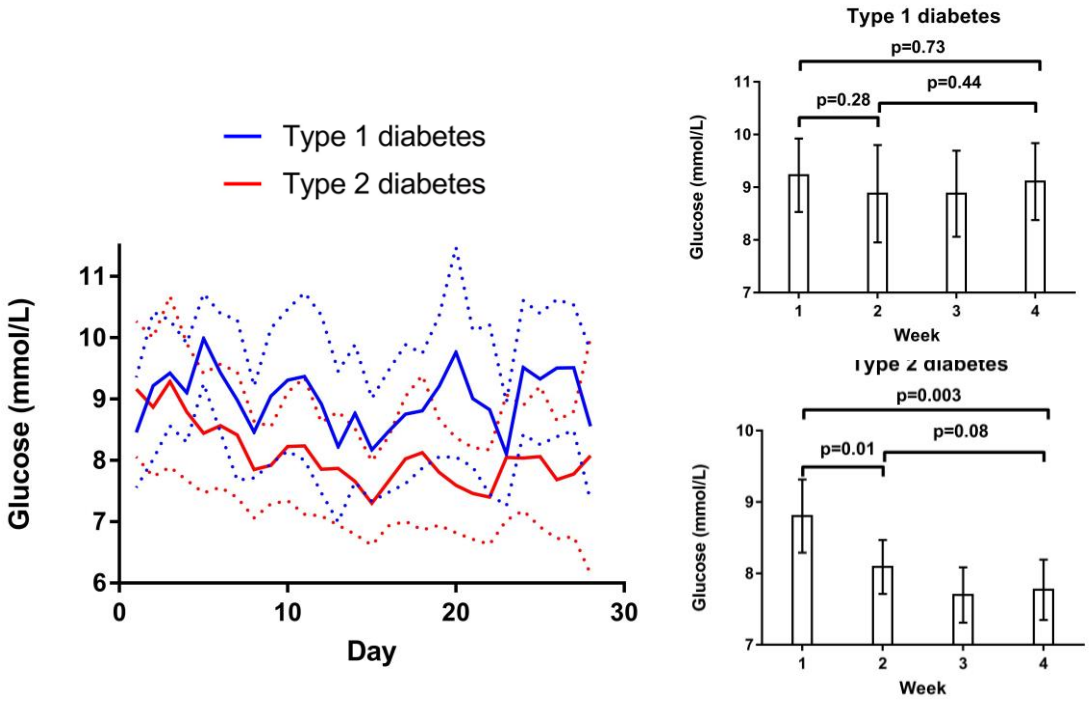

Figure 2.2.3. Analysis of mean glucose data during Phase 1 on the QC.

Halting intensive self-monitoring may lead to worsening of glycemic control (Figure 2.2.4).

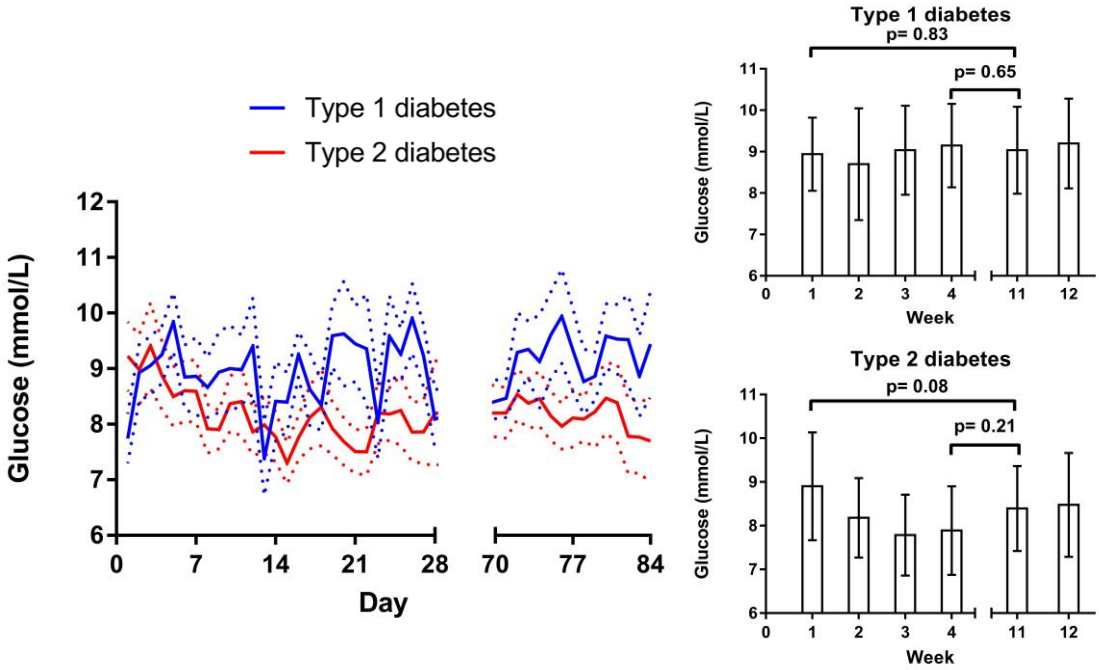

Figure 2.2.4. Analysis of mean glucose data during Phase 1 and Phase 2 of the QC.

There was no correlation between HbA1c at baseline and change in glucose over 4 weeks (R^2=0.01; p=0.54) (Figure 2.2.5).

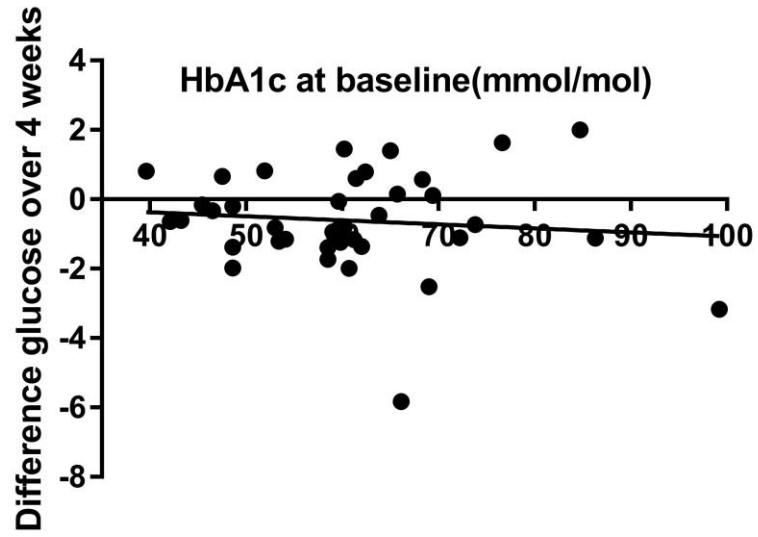

Figure 2.2.5. Analysis of correlation between HbA1c at baseline and change in mean glucose data during Phase 1 of the QC.

A significant decrease in glucose variability was observed for type-2, but not for type-1 diabetes patients (Figure 2.2.6).

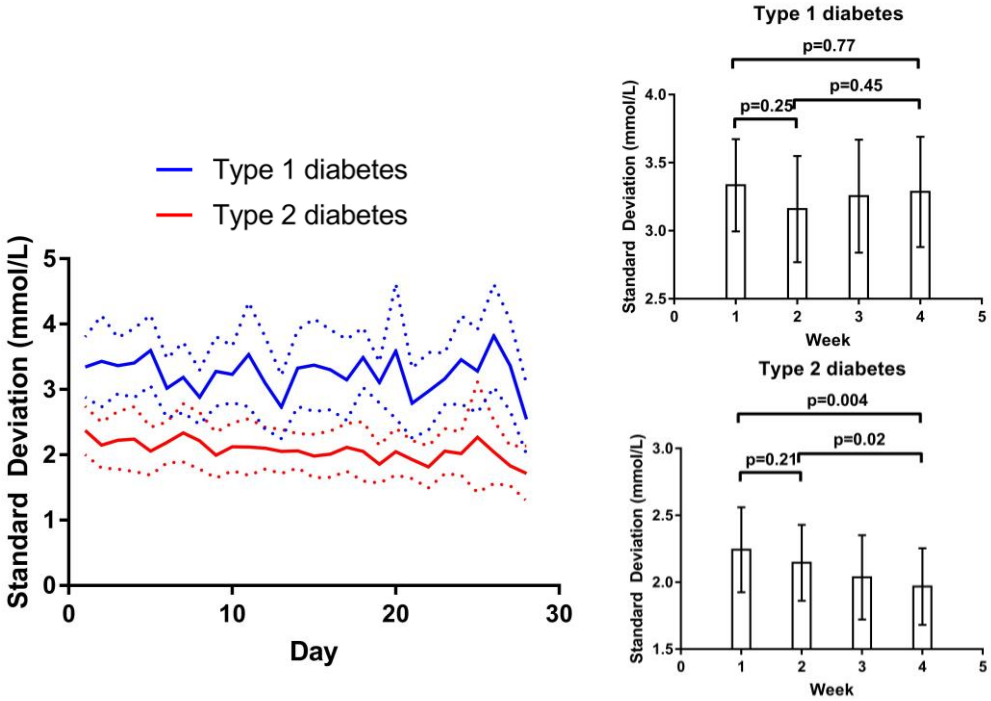

Figure 2.2.6. Analysis of glucose variability during Phase 1 of the QC.

Time spent in hypoglycemia did not change during the 30 days of the QC (Figure 2.2.7).

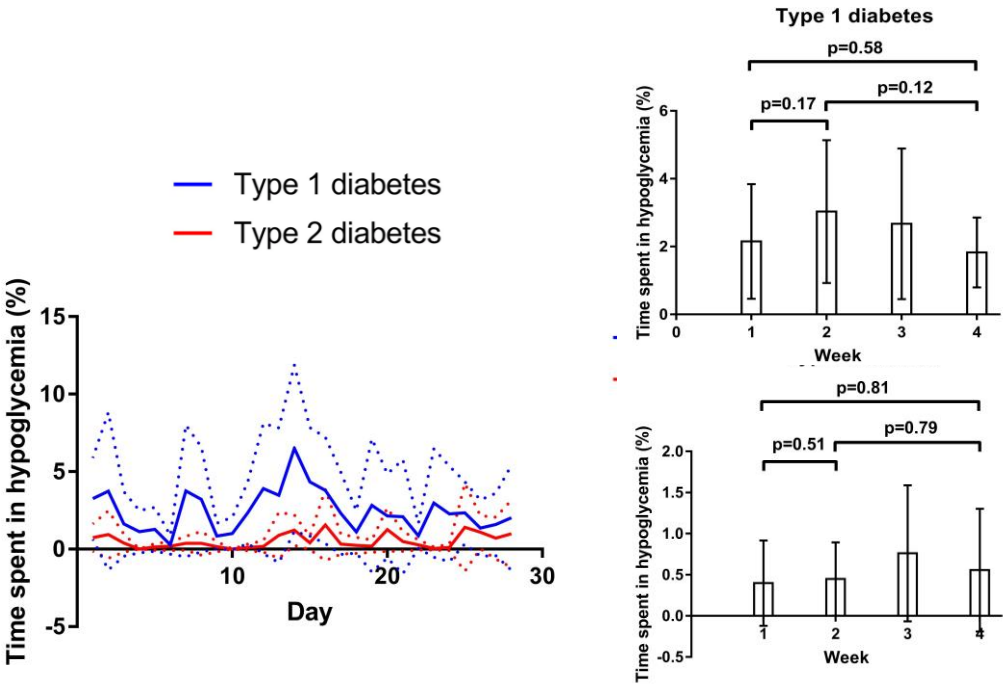

Figure 2.2.7. Analysis of hypoglycemia observed during Phase 1 of the QC.

3 PILOT DATA AND INTERVIEWS TO ASSESS USER EXPERIENCES.

During the Quantification Campaign, potential issues that may impede implementation of the POWER2DM prototype in the real-world setting that is to be tested in the pragmatic trial (Evaluation Campaign) were analysed. The outcome of these analyses was already presented previously in Deliverable 6.2 "D6.2.1 Description of the Quantification Campaign Dataset". Further relevant suggestions were obtained from the Feasibility Studies as previously reported in D5.4 "D5.3.1 Feasibility Studies Outcome". No further result from the Quantification Campaign on user experiences are foreseen.

4 CONCLUSION

Refined power calculations based on the Quantification Campaign data on variability of HbA1c levels showed that a reduced sample size is required for the EC: 230 patients compared to 280 (in DoA).

Data analysis of the POWER2DM QC for evaluation of the KADIS model was unsuccessful so far due to deficient data collection and difficulties in preparing an integrated dataset.

Analysis of the mHealth data derived from Spire and Fitbit devices so far did not produce results due to high variability in the data and relatively high fraction of missing data, requiring labour-intensive tailored approaches for possible further progress.

Analysis of the FSL Flash Glucose Monitoring data showed a decrease of HbA1c in both type-1 and type-2 diabetes patients, and a decrease in average glucose and glucose variability in type-2 diabetes patients only. No effects on hypoglycemia were seen. Type-1 and type-2 diabetes patients thus seem to benefit differentially from intensive monitoring of lifestyle parameters.

The ongoing Evaluation Campaign is currently given priority over further labour-intensive attempts required to possibly obtain additional result from the QC dataset.