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SYMPOSIUM

The Karlsburg Diabetes Management System: Translation from Research to eHealth Application

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Abstract

Background:

Several telemedicine-based eHealth programs exist, but patient-focused personalized decision support (PDS) is usually lacking. We evaluated the acceptance, efficiency, and cost-effectiveness of telemedicine-assisted PDS in routine outpatient diabetes care.

Methods:

Data are derived from the Diabetiva® program of the German health insurance company BKK TAUNUS. Diabetiva offers telemedicine-based outpatient health care in combination with PDS generated by the Karlsburg Diabetes Management System, KADIS®. This retrospective analysis is based on data from the first year of running KADIS-based PDS in routine diabetes care. Participants were insured persons diagnosed with diabetes and cardiovascular diseases. For final analysis, patients were grouped retrospectively as users or nonusers according to physician acceptance or not (based on questionnaires) of the KADIS-based PDS.

Results:

A total of 538 patients participated for more than one year in the Diabetiva program. Of these patients, 289 had complete data sets (two continuous glucose monitoring measurements, two or more hemoglobin A1c (HbA1c) values, and a signed questionnaire) and were included in the final data analysis. Of the physicians, 74% accepted KADIS-based PDS, a rate that was clearly related to HbA1c at the beginning of the observation. If KADIS-based PDS was accepted, HbA1c decreased by 0.4% (7.1% to 6.7%). In contrast, rejection of KADIS-based PDS resulted in an HbA1c increase of 0.5% (6.8% to 7.3%). The insurance company revealed an annual cost reduction of about 900 € per participant in the Diabetiva program.

Conclusions:

KADIS-based PDS in combination with telemedicine has high potential to improve the outcome of routine outpatient diabetes care.

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Abbreviations: (BMI) body mass index, (CGM) continuous glucose monitoring, (CTP) characteristic daily glucose profile, (HbA1c) hemoglobin A1c, (MSG) mean sensor glucose, (OHA) oral hyperglycemic agents, (PDS) personalized decision support, (SG) sensor glucose

Keywords: advisory system, continuous glucose monitoring, eHealth, HbA1c, KADIS, outpatient diabetes care, patient-focused decision support, retrospective outcome analysis, telemedicine

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Introduction

Several studies[1–4] have convincingly shown that lowering hemoglobin A1c (HbA1c) in patients with diabetes reduces or prevents diabetes-related complications. However, translation of these results into routine diabetes care by implementing guidelines into the current management of diabetes[5–7] has been disappointing. About 60% of diabetes patients did not reach the recommended glycemic targets,[8] leading to the question of why this goal is so hard to achieve. Several primary obstacles that might be responsible have been identified in the current diabetes health care systems: (i) conservative management, (ii) long-lasting therapeutic approaches, (iii) insufficient communication between patients and care providers, and (iv) an absence of reasonable and powerful decision-support systems to transfer existing knowledge and experience into practice. Apparently, many diabetes health care systems lack new technologies, including evidence-based decision-support systems,[9] screening, or daily remote monitoring and are based chiefly on episodic encounters between patients and their care providers, thus remaining ineffective. In light of these deficits and the increasing numbers of patients with type 2 diabetes and people at risk of developing diabetes, diabetes-related hospitalizations and health care costs have dramatically increased.[10]

The Karlsburg Diabetes Management System, KADIS®, was developed to improve the quality and cost-effectiveness of diabetes care and management for patients with type 1 or type 2 diabetes.[11–15] KADIS is derived from the Karlsburg model of glucose–insulin interactions,[16] and it generates an *in silico* copy of the individual metabolic profile of a given patient (a personalized "metabolic fingerprint") on the computer and allows testing of different therapeutic measures by interactive *in silico* simulation procedures aimed at quickly and safely identifying a regimen that may provide individually optimal glucose control.[13,14,17] The results of the simulation procedure are summarized as patient-focused personalized decision support (PDS) for the responsible physicians. For implementation of KADIS-based PDS into routine diabetes care, the program is combined with continuous glucose monitoring (CGM) and a telemedicine-based communication and information platform (TeleDIAB®).

The KADIS-based PDS has been tested and verified in type 1 as well as type 2 diabetes in different clinical studies, all of which showed significant reductions in HbA1c values and clear improvement of metabolic control.[12,15] Based on these results, a German health insurance company, BKK TAUNUS, in cooperation with the telemedicine provider SHL Düsseldorf and the Diabetes Service Center Karlsburg (DCC®), initiated a regionally centered pilot trial, designated Diabetiva®, to test KADIS-based PDS under daily life conditions in the environment of routine diabetes care. Participants in this pilot trial were insured persons diagnosed with diabetes and cardiovascular diseases. The results have convinced the health insurance company to roll out Diabetiva countrywide based on a contract for Integrated Health Care according to § 144 of the German Social Law Book V.

To evaluate the acceptance, outcome, and cost-effectiveness of implementing PDS in combination with telemedicine-supported home monitoring in routine diabetes care, after one year of running KADIS, we performed a before/after analysis of the accumulated data. To elucidate the effect of KADIS-based PDS, we grouped patients after running the Diabetiva program for 12 months into users (KADIS-based PDS applied) or nonusers of PDS (KADIS-based PDS denied) according to physician responses to questionnaires and evaluated the data retrospectively.

Methods

Diabetiva Program

The Diabetiva program, launched by BKK TAUNUS in 2007, provides insured patients with diabetes and/or cardiovascular diseases access to the KADIS-based PDS. Diabetiva is a telemedicine-supported, integrated health care network linking BKK TAUNUS, SHL Düsseldorf, the DCC, outpatient settings, and insured patients. Diabetiva is open for patients with type 1 or type 2 diabetes who are at least 18 years old, were diagnosed with diabetes, are able to understand and to perform CGM, and were diagnosed with cardiovascular disease (angina pectoris, history of myocardial infarction, or heart failure New York Heart Association grade 3–4).

The timeline of the Diabetiva program is given in **Figure 1**. After participants enter the program, current HbA1c values are measured and participants perform a 72 h CGM under daily life conditions, as previously described.[13,16,18] The CGM data are downloaded and transferred together with basic patient data [age, gender, type of diabetes, duration of diabetes, body mass index (BMI)] and self-control data (HbA1c, medication, meals,

exercise) to the DCC for generation of the KADIS-based PDS, which is summarized in a KADIS report and provided to the participating physicians together with a questionnaire. In this questionnaire, physicians document whether they have accepted or denied the provided PDS. This procedure is repeated every 12 months. Between the two CGMs, HbA1c is determined quarterly in combination with a medical checkup. Telemedicine-supported observation and analysis of point-of-care home blood glucose measurements, body weight, and electrocardiogram are performed on an ongoing basis for all participating patients by the specialized telemedicine provider, SHL Düsseldorf, as described previously.[19] All Diabetiva participants receive a HomeCareCenter™ (SHL Düsseldorf) that enables the automatic transfer of data [blood glucose (LifeScan One Touch Blood Glucose Meter), blood pressure (TelePress™, SHL Düsseldorf), body weight (TeleWeight™, SHL Düsseldorf), and, as required for comorbidity coronary heart disease, heart rate (12-lead electrocardiogram CardioBeeper® CB-12/12™, SHL Düsseldorf) via the home phone to a telemedicine-based health care center. The glucose and blood pressure measurements were transferred to the health care center day by day, the body weight once a week, and the electrocardiogram, if necessary.

For the evaluation of the effect of KADIS-based PDS on metabolic control, the participating patients were grouped after 12 months of running the Diabetiva program into users (PDS accepted) and nonusers (PDS denied) according to the questionnaires completed by the physicians. Patient HbA1c and CGM profiles at the beginning and after one year were retrospectively analyzed and compared.

KADIS-Based Personalized Decision Support

KADIS is a clinically proven software system that allows identification and visualization of an individual metabolic profile (a personalized *in silico* copy) on a computer and generation of patient-focused treatment recommendations for the responsible physicians in terms of a PDS.[11–15] **Figure 2** illustrates the entire procedure.

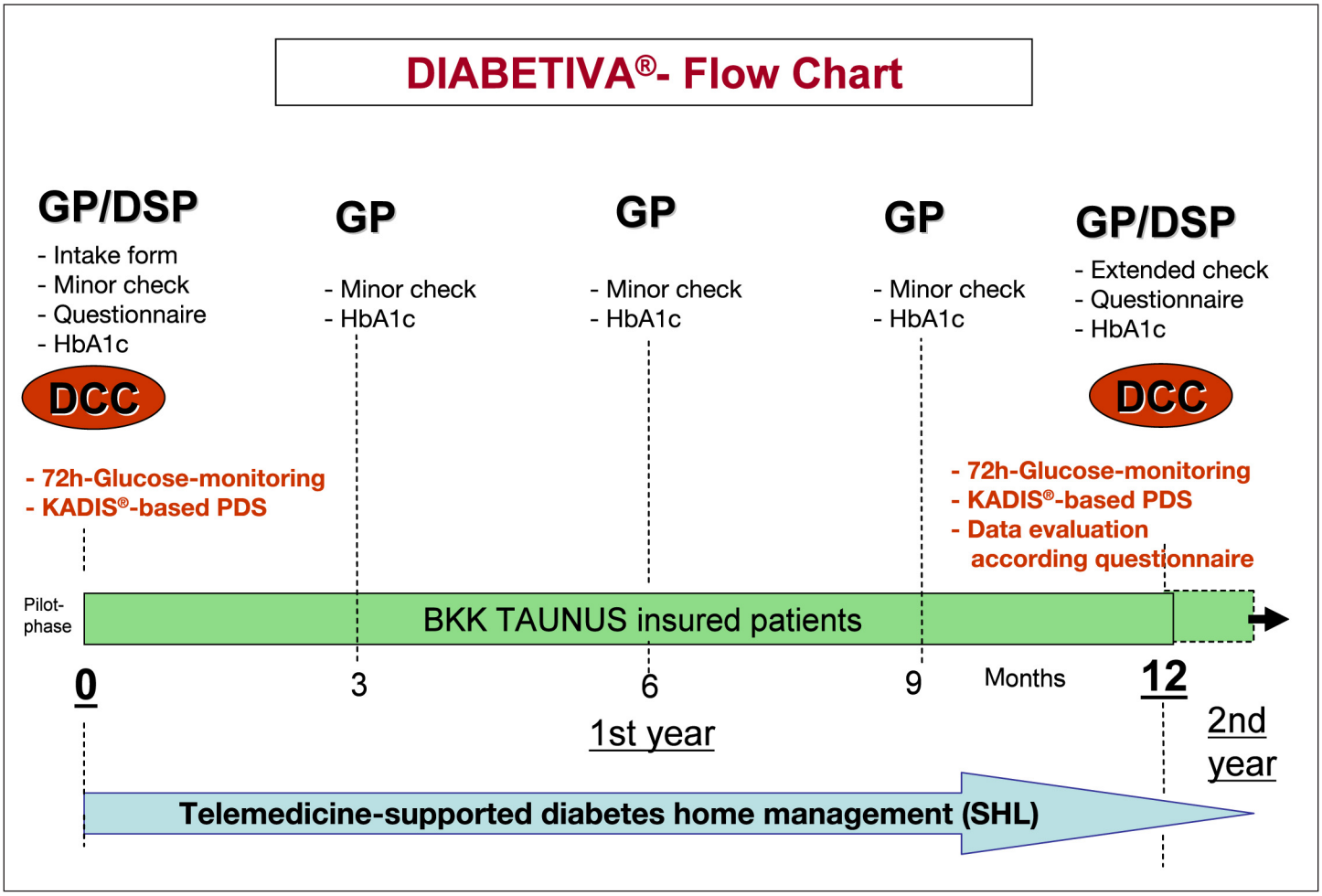

Figure 1. Flow chart of the Diabetiva program. GP, general practitioner; DSP, diabetes specialist.

After input of the baseline characteristics of age, gender, BMI, and onset and type of diabetes (basic data); the CGM profiles (CGM data); and the therapeutic measures in relation to meals and exercise (self-control data) into the computer, in a first step, the characteristic daily glucose profile (CTP) of a given patient is calculated. Next, the KADIS program estimates automatically the so-called personalized "metabolic fingerprint," which relates the CTP to individual KADIS-based calculated endogenous (e.g., 24 h profiles of insulin secretion, insulin resistance,

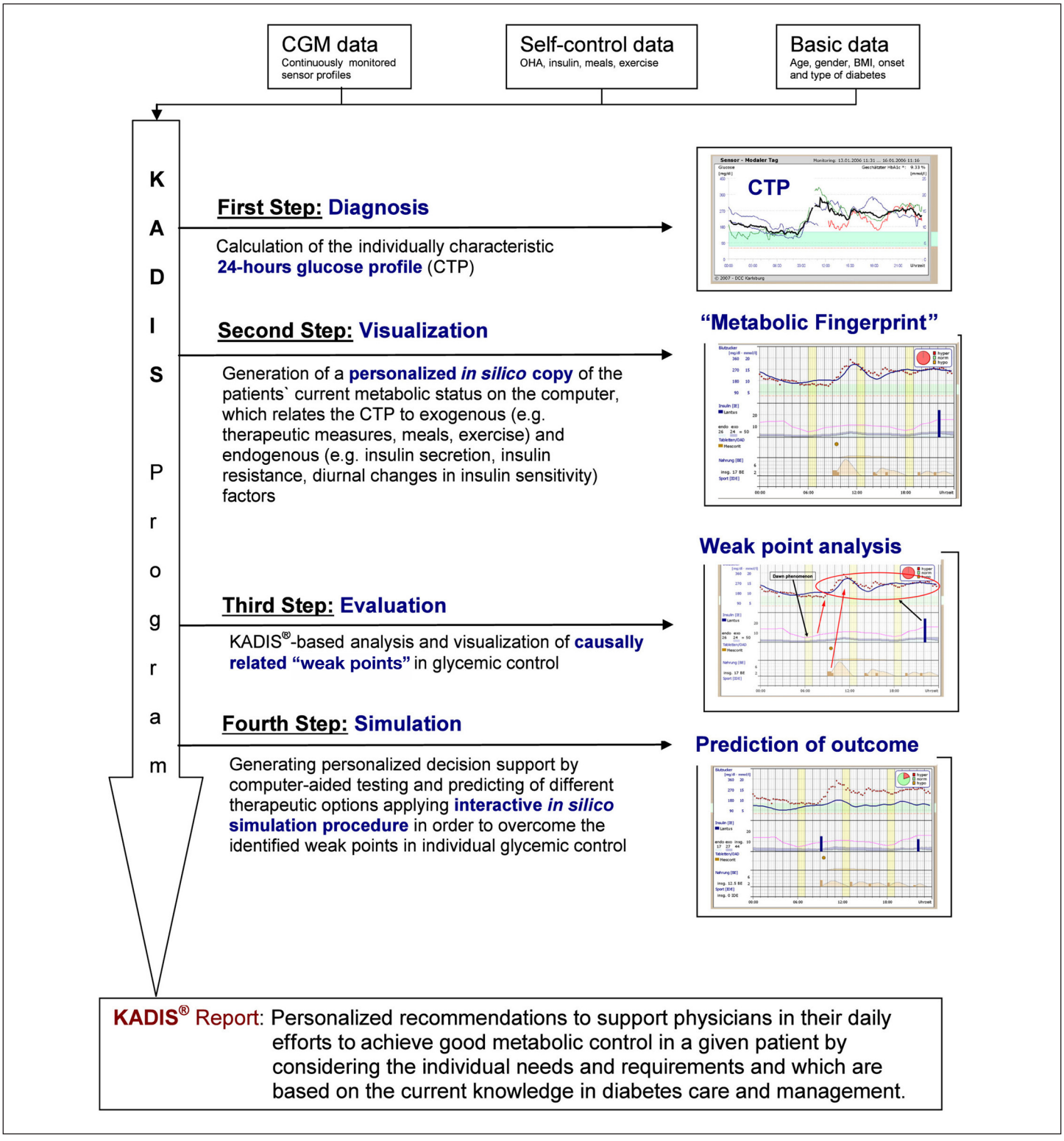

Figure 2. Main components of generating the KADIS-based PDS.

diurnal changes in insulin sensitivity, and hepatic glucose output) and exogenous (patterns of meal absorption, exercise action profiles, and action profiles of different medications) factors. The results describing the current metabolic status are visualized on the computer screen.

The next step is to identify and reveal causally related "weak points" in the current metabolic control. "Weak points" are considered as episodes of unsatisfactory control in CGM, e.g., episodes of hyperglycemia or hypoglycemia, which may be related to insufficient therapeutic measures and/or endogenous factors such as diurnal high or low insulin sensitivity, amount of endogenous insulin secretion, or overall individually quite different insulin sensitivity. The last step of the program is directed at generating therapeutic recommendations by an interactive *in silico* simulation procedure based on the guidelines of the German Diabetes Association[5] that describes what might be most suitable for a given patient to overcome the identified weak points. To meet this goal, different therapeutic measures are tested in the DCC by specially trained telemedicine operators under the supervision of experienced physicians, and the expected outcome for glycemic control is predicted. In this way, patient-focused therapeutic measures can be selected quickly and safely without time-consuming and costly experimental trial-and-error procedures. The results are finally summarized as a PDS, which is provided to the responsible physician as a KADIS report.

Statistical Analysis

All statistical analyses were carried out using the Statistical Package for the Social Sciences Version 17.0 (SPSS, Chicago, IL). Results are given as mean ± standard deviation for normally distributed parameters or as median and interquartile range for the non-normally distributed parameters of insulin dose, hyperglycemia, and hypoglycemia. Mean sensor glucose (MSG) and the time for glucose values in the hyperglycemic (>160mg/dl) and hypoglycemic (<60 mg/dl) range were calculated from each continuously recorded glucose profile. The ΔHbA1c is the difference in HbA1c values between the second and first CGM runs. Group comparisons were evaluated using unpaired Student's *t*-tests or the Mann–Whitney U test as appropriate. Categorical variables were compared using the chi-square test. Within-group changes were tested by paired *t*-tests or Wilcoxon tests as appropriate. Multiple regression analysis with stepwise forward selection was performed to identify the variables related to **Δ**HbA1c. Independent variables were HbA1c at entry into the Diabetiva program, physician specialty (diabetes specialist, general practitioner), diabetes type, sex, age, BMI, and use or nonuse of KADIS-based PDS. The level of statistical significance was set at $p = .05$.

Results

Basic Characteristics of Patients in the Diabetiva Program

A total of 538 BKK TAUNUS-insured persons participated after 12 months of running Diabetiva. A minority suffered from type 1 diabetes (4.1%), and 289 of the participants had complete data sets (two CGMs 12 months apart, completed questionnaires, and two HbA1c measurements at the beginning and after 12 months) and could therefore be considered for the final retrospective data analysis. These patients were treated by 236 general practitioners and 40 diabetes specialists. **Table 1** summarizes the basic characteristics of these patients.

The average age of the participating patients was 65.0 ± 9.7 years, and the mean duration of diabetes was 12.1 ± 9.6 years. A total of 10% (29/289) of the participants were treated without medication, 31% (89/289) received oral hyperglycemic agents (OHA), and 59% (171/289) were on insulin therapy with or without combinations with OHA. The patients in all therapeutic groups were slightly overweight: mean BMI = 30.7 kg/m^2 (target, <25 kg/m^2). With the exception of the diet group (6.4 ± 1.0%), the HbA1c at the beginning exceeded the recommended target range of <6.5% in all other therapeutic groups (means, 6.9% to 7.3%). Only 24% of the patients in the insulin-treated groups met the HbA1c target range of <6.5%. The CGM profiles data clearly confirm these findings; approximately 42% of the measured glucose values failed to meet the recommended target range of 60 to 160 mg/dl.

Acceptance of KADIS-Based Personalized Decision Support

According to the questionnaires completed by the participating physicians, there was an overall acceptance rate of approximately 74% (214/289). The acceptance of PDS was clearly related to HbA1c values at baseline (**Figure 3**). The highest acceptance rates were found for patients with baseline HbA1c values above 7.5% and the lowest for patients with baseline HbA1c values between 6.5% and 7.0%. These findings did not differ between general practitioners and diabetes specialists. Most noteworthy were the results for baseline HbA1c values <6.5%; the analysis revealed in both groups of physicians an increase in acceptance rates for PDS.

Table 1.
Basic characteristics of the 289 Insured Patients Participating in Diabetiva Who Had Completed Data Sets after One Year of Running the Program[a]

Parameter	Diet	OHA	OHA + insulin	Insulin	Total
N	29	89	67	104	289
Age (years)	65.0 ± 8.0	65.7 ± 9.6	64.6 ± 8.2	64.7 ± 11.0	65.0 ± 9.7
DD (years)	4.6 ± 4.4	7.8 ± 6.7	12.7 ± 7.5	17.0 ± 10.9	12.1 ± 9.6
BMI (kg/m^2)	29.5 ± 4.4	29.9 ± 4.8	32.8 ± 5.5	30.4 ± 5.3	30.7 ± 5.2
HbA1c (%)	6.4 ± 1.0	6.9 ± 0.9	7.3 ± 1.0	7.2 ± 1.0	7.1 ± 1.0
HbA1c <6.5% (%)	69.6	36.5	24.8	23.5	31.8
BG in target range (h)	20.3 ± 5.8	17.5 ± 7.0	14.7 ± 7.5	14.2 ± 7.9	15.9 ± 7.6

[a] These patients were treated by 276 physicians (236 general practitioners and 40 diabetes specialists). Data are given as mean ± standard deviation. Blood glucose target range: 60–160 mg/dl. BG, blood glucose; DD, diabetes duration.

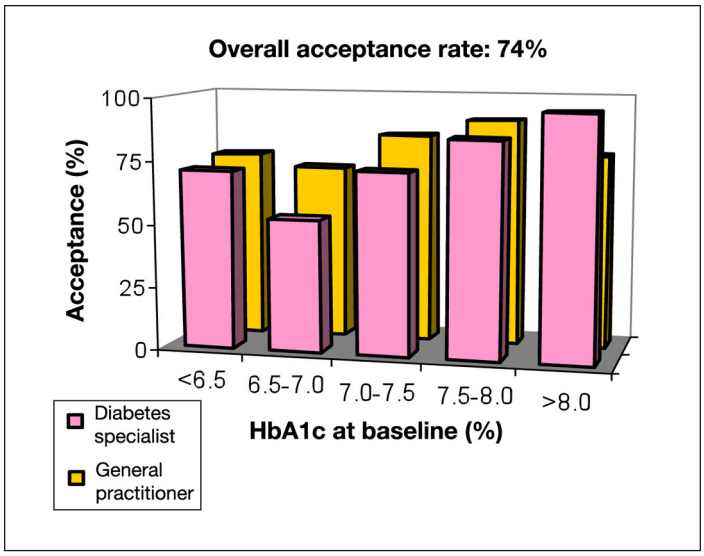

Figure 3. Acceptance rate of KADIS-based PDS by general practitioners or diabetes specialists in relation to baseline HbA1c.

Medical Outcome of Personalized Decision Support in Routine Diabetes Care

For evaluation of the medical outcome of KADIS-based PDS, the data obtained from 289 patients after one year of running the Diabetiva program were grouped into users or nonusers of PDS according to how physicians responded to the questionnaires. These data were retrospectively analyzed by comparing the measured HbA1c values and CGM profiles at the beginning and after 12 months. **Table 2** and **Figure 4** summarize the results.

In patients for whom the responsible physicians accepted and applied KADIS-based PDS, significant reductions of HbA1c (7.1% to 6.7%) and mean CGM profiles (MSG, 139 to 133 mg/dl) were identified (**Table 2**). The percentage of HbA1c levels in the recommended target range of <6.5% increased from 32.7% to 46.7%. In addition, these improvements were accompanied by a reduction of 0.6 h/day (4.2 to 3.6 h/day) in which the CGM profiles were in the hyperglycemic range of above 160 mg/dl. This result is also reflected by the increased percentage of the 24 h sensor glucose (SG) values within the target range (82.5% to 85.0%). Of importance, the time below the target range of 60 mg/dl was unaffected.

In contrast, in the group of patients whose physicians denied KADIS-based PDS, the HbA1c values increased significantly by 0.5% (6.8% to 7.3%), and the percentage of HbA1c values within the target range of <6.5% decreased from 34.7% to 16.0%. The MSG did not change significantly (146 to 148 mg/dl), but there was a tendency of the measured SG profiles to worsen (**Table 3**).

Multiple regression analysis demonstrated that ΔHbA1c (i.e., the difference between HbA1c values at the beginning and after one year of observation) was significantly related to use or nonuse of KADIS-based PDS (β = -0.608, standard error = 0.097, $p < .0001$) and HbA1c at baseline (β = -0.333, standard error = 0.051, $p < .0001$; $R = 0.664$). Age, sex, diabetes duration, diabetes type, physician specialty, and BMI had no additional influence. **Figure 4** shows the results for ΔHbA1c (%) in relation to HbA1c at baseline and in relation to use or nonuse of KADIS-based PDS.

The effect of use or nonuse of KADIS-based PDS was most evident in the baseline HbA1c values between >6.5% and <8.0%. In these groups, HbA1c decreased when PDS was applied and increased when PDS was denied (**Figure 4**).

Table 2.
Effects of Use (N = 214) or Nonuse (N = 75) of KADIS-Based Decision Support on the Medical Outcome after One Year of Running Diabetiva[a]

Outcome parameter	KADIS -based PDS used		KADIS-based PDS not used	
	At the beginning	After one year	At the beginning	After one year
HbA1c (%)	7.1 ± 0.9	6.7 ± 0.8[b,c]	6.8 ± 08	7.3 ± 0.8[b]
HbA1c <6.5% (%)	32.7	46.7	34.7	16.0
MSG (mg/dl)	139 ± 29	133 ± 23[b,c]	146 ± 29	148 ± 34[c]
SG >160 mg/dl (h/day)	4.2	3.6	5.7	6.1
SG <60 mg/dl (h/day)	0.03	0.02	0.02	0.02
SG in target range (%)	82.5	85.0	76.2	74.6

[a] Data are given as mean ± standard deviation. Target range for SG profile: 60–160 mg/dl.
[b] $p < .05$ versus beginning of PDS.
[c] $p < .05$ versus nonuse of PDS.

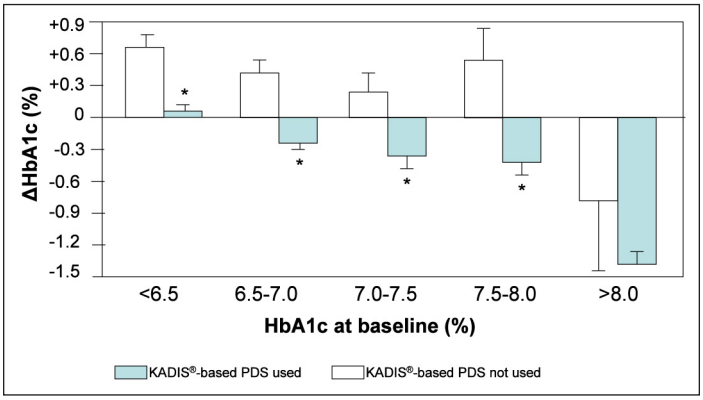

Figure 4. Differences in HbA1c values (ΔHbA1c) between the beginning and after one year of running Diabetiva in relation to baseline HbA1c and use or nonuse of KADIS-based PDS. The asterisk represents $p < .05$ for differences between use or nonuse of PDS; data are mean ± standard deviation.

Table 3.
Health Care Costs

	Diabetiva	Control group	Costs
Medication and treatment devices	1838 €	1052 €	+786 €
Clinical care	6732 €	11,278 €	-4546 €
Telemedicine + PDS	2850 €	0 €	+2850 €
Total	11,420 €	12,330 €	-910 €

The greatest effect on ΔHbA1c was observed in patients with baseline HbA1c values >8.0%. In this group, HbA1c decreased independently of use or nonuse of PDS, but the decrease was more pronounced in the user group.

The observed link between the HbA1c at baseline and the acceptance rates (**Figure 3**), initiated a second multiple regression analysis revealing significant relations between the HbA1c outcome (ΔHbA1c) and the HbA1c at baseline (β = -0.299 ± 0.034, $p < .0001$) as well as a significant interaction (β = -0.105 ± 0.011, $p < .0001$) with the acceptance rates. This interaction coefficient contributes to different ΔHbA1c in relation to use or nonuse of PDS. In the user group the interaction coefficient has a stronger influence on the ΔHbA1c in comparison to the nonuser group, i.e., if the interaction coefficient is not considered in the multiple regression analysis we have to expect a slight underestimation of the influence of use of PDS on the outcome in case of usage. But basically, the different interaction coefficients between the user and the nonuser groups have only a minor influence on the results of the multiple regression analysis.

Cost Effectiveness

The results concerning the cost-effectiveness of telemedicine-assisted PDS in routine diabetes care were derived from data presented by BKK TAUNUS. The insurance company reported an annual cost reduction per patient participating in the Diabetiva program (personal communication in 2009). There was an increase in the cost of medication and additional costs for financing the Diabetiva program. But there was a stronger reduction in costs for diabetes-related hospitalizations (see also Discussion).

Discussion

Diabetes is the most prevalent chronic disease worldwide, and related morbidity and mortality rates are increasing dramatically.[20] The large increase in diabetes prevalence from 4.6% to 6.4% has led the World Health Organization to declare diabetes a significant danger. Actions have been

undertaken worldwide to find new approaches for the prevention and treatment of the disease.[21] In particular, the discrepancy between existing knowledge about evidence-based metabolic control summarized in guidelines and the implementation lacking in routine diabetes care needs to be overcome.[7–9] In Germany, the analysis of the Diabetiva program performed after 12 months of implementation into routine diabetes care also indicated suboptimal diabetes care. Initially, approximately 30% of diet-treated diabetes patients, 76% of insulin-treated patients, and 64% of OHA-treated patients did not meet the HbA1c target range of <6.5% as recommended by the guidelines of the German Diabetes Association.[5]

New approaches to improving diabetes care include a text messaging support system, mobile phone-based data service, teleconsultation, and video conferencing.[22–24] Although improvement in quality of life, satisfaction with technology, and better access to care have been reported, the effects on improving metabolic control by these approaches have been less convincing.[24] In our findings, we demonstrated an approach to transferring successfully existing know-how and experiences into routine diabetes care by applying a PDS system in combination with telemedicine-assisted communication tools, including home monitoring. An indispensable precondition to running such programs in routine diabetes care might be to form appropriate health care networks including physicians, health care insurance funds, health care service providers, and patients. Our approach fulfilled this precondition by establishing the Diabetiva network.

Within the Diabetiva network, the PDS is generated by using KADIS, the Karlsburg Diabetes Management System. Application of KADIS-based PDS resulted in significantly improved metabolic control for patients and revealed considerable acceptance by the responsible physicians. This retrospective evaluation after running the Diabetiva program for 12 months confirmed that HbA1c levels decreased significantly, by approximately 0.4%, if KADIS-based PDS was incorporated into routine diabetes health care. These results confirm earlier findings of experimental studies performed to test and evaluate the efficacy and efficiency of the KADIS program.[12,15,25] Consistent with our findings here, the improved metabolic control, as demonstrated by a reduction in HbA1c levels, was accompanied by a reduction in both the mean blood glucose values and hyperglycemic episodes.[12,15,25] Of importance, these improvements did not enhance the risk of hypoglycemia.

All KADIS-related studies performed so far have identified a relationship between the observed KADIS effects and HbA1c at baseline; the higher the HbA1c at baseline, the greater the effect of KADIS-based PDS.[12,15,25] For example, in a case-control study, KADIS-based PDS resulted in a 0.8% reduction in HbA1c for patients with HbA1c >8.0% at baseline within 3 months. The results obtained in our current retrospective outcome analysis confirm these findings. Application of KADIS-based PDS in diabetes patients with HbA1c >8.0% at baseline resulted in a reduction of HbA1c by 1.3% within the first 12 months of running Diabetiva.

The limitations of this report lay in the nature of a retrospective outcome analysis. We cannot exclude that different confounders, such as the style in which physicians manage their patients or the compliance of the patients themselves, may have influenced our results. However, at the beginning of the observation, all participating physicians were provided with completely the same information, including KADIS-based PDS, and all patients received the same telemedicine-based support, including home care devices, independently of the ongoing use or nonuse of the PDS. The grouping of the patients into user or nonuser of PDS for analysis of the outcome data is based on the decision of the participating physicians, who informed the DCC about the use or nonuse of the PDS by problem-related questionnaires. For further enhancement of the evidence of the results obtained in this retrospective outcome analysis, future long-term studies need to be performed as randomized clinical trials applying PDS in routine diabetes care.

The main advantage of KADIS-based PDS is the contribution to a reduction in HbA1c and subsequently improvement of routine diabetes care without increasing the risk for hypoglycemia. The Diabetes Control and Complications Trial and United Kingdom Prospective Diabetes Study have convincingly demonstrated that development of diabetes-related complications can be influenced or stopped to a certain extent if appropriate measures are incorporated into the diabetes health care process. If HbA1c can be decreased below 6.5%, the risk for blindness, amputation, kidney failure, and neuropathy will be reduced remarkably.[4] To meet this goal, blood glucose levels should be kept close to normal throughout the day to achieve long-term HbA1c target values of <6.5%.[5] Our findings obtained so far clearly demonstrate that this reduction might be possible under routine diabetes care conditions if PDS systems are appropriately implemented into the entire health care process.

Moreover, BKK TAUNUS has found that application of KADIS-based PDS in combination with telemedicine-assisted home monitoring is suitable to reduce the annual health care costs per insured patient by about 900 € as summarized in **Table 3**. There was an increase in the costs of medication and of costs for financing the telemedicine-supported health care services, including PDS, provided by the Diabetiva program. These enhanced costs, however, were completely compensated by the reduction in both the number of diabetes-related hospitalizations and the duration of clinical care. These findings demonstrate how innovative health care technologies can contribute to providing efficient and cost-effective routine diabetes care on a long-term scale.

Cost efficiency of the Diabetiva program was evaluated by BKK TAUNUS after one year of running the program in routine diabetes care by comparing the patient-related annual costs of the 289 participants in Diabetiva with 300 patients (control group) who were treated without telemedicine-assisted PDS.

In summary, the application of KADIS-based PDS within the Diabetiva program in terms of an eHealth application resulted in a reduction of HbA1c by 0.4% after one year of follow-up. Our findings indicate that PDS holds promise in the prevention of late complications in diabetes care.[4,26] The convincing results of the first evaluation, the positive response of the participating physicians and patients, and the preliminary positive medical outcome demonstrate the great potential of PDS to improve diabetes health care significantly. Personalized decision support in combination with telemedicine-based approaches may substantially contribute to success in the worldwide struggle against diabetes and its burden.

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