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SYMPOSIUM

Telemedicine Diabetes Consultations Are Cost-Effective, and Effects on Essential Diabetes Treatment Parameters Are Similar to Conventional Treatment: 7-Year Results from the Svendborg Telemedicine Diabetes Project

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Abstract

Background:

The increasing number of patients with diabetes poses a major challenge for the health care system. One instrument to meet these challenges could be the use of telemedicine, which, at the same time, may reduce treatment costs. Since 2005, diabetes patients on the island of Aeroe have been offered expert diabetes care using teleconsultations. This article describes the impact of the telemedicine solution on essential diabetes treatment parameters, patient satisfaction, and cost-effectiveness.

Methods:

Telemedicine consultations were conducted with the patient and nurse specialist placed in a consultation room of Aeroe Hospital in audiovisual contact with the physician situated at the hospital on the mainland. Consultations were supported by an electronic patient record and a Web-based quality-monitoring diabetes database.

Results:

Inclusion criteria in this retrospective study were at least 6 months of telemedicine diabetes control with a minimum of two visits and two hemoglobin A1c (HbA1c) values. Results were compared with data from the Danish National Diabetes Registry (DVDD). Data are given in medians. In total, 23 type 1 diabetes mellitus (T1DM) patients, aged 65 (56–74) versus 48 years, diabetes duration 21.0 (10.7–31.3) versus 20.5 years, and 55 type 2 diabetes mellitus (T2DM) patients, aged 67 (64–70) versus 65 years, diabetes duration 14.0 (10.5–17.5) versus 11.7 years, were included. After teleconsultation, HbA1c in T1DM patients was 8.0% (7.4–8.6%) versus 7.9% [64 (57–71) versus 63 mmol/mol], not significant, and in T2DM patients was 7.4% (7.1–7.7%) versus 7.6% [57 (54–61) versus 60 mmol/mol], $p < .05$. Body mass index, blood pressure, and lipid values were comparable with the DVDD. Patient satisfaction was especially related to the major reduction in transportation time (7 h). Reductions in traveling costs and saved working days were the most important factors in making the telemedicine set-up economically efficient.

continued →

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Abbreviations: (dkr) Danish kroner, (DVDD) Danish National Diabetes Registry, (HbA1c) hemoglobin A1c, (ICT) information and communication technologies, (T1DM) type 1 diabetes mellitus, (T2DM) type 2 diabetes mellitus

Keywords: cost-effectiveness, diabetes, telemedicine, videoconferencing

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Abstract cont.

Conclusion:

Telemedicine consultation for remote outpatient diabetes control is feasible, and the interdisciplinary interventions achieved high treatment quality results in essential diabetes treatment parameters. In addition, the telemedicine set-up was associated with improved cost-effectiveness and patient satisfaction.

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Introduction

Diabetes mellitus is a common chronic disease that requires lifelong medical care and control as well as ongoing patient self-management, education, and support to prevent acute complications and to reduce the occurrence of long-term complications. Currently, diabetes affects approximately 5% of the population worldwide, with rising incidence and prevalence rates for both type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM).[1–3] Although the high prevalence rate of diabetes in itself is alarming, it also poses a major challenge for the health care system, including the foreseen shortage of highly qualified medical professionals. Moreover, Western countries share the dilemma of having to provide high-quality health care to an increasing quality-aware and demanding population in the face of ever-increasing pressure on budgets.

Telemedicine could be used as an instrument to meet the challenges in diabetes management and, at the same time, to reduce treatment costs.[4,5] Essentially, telemedicine can be classified as either synchronous (real time) or asynchronous (not real time) interaction.[6] Synchronous technologies refer to the use of information and communication technologies (ICT) that, over short and long distances, connect caregivers and patients simultaneously, including face-to-face contact (image and voice) via videoconferencing equipment (television, Webcam, videophone). Asynchronous telemedicine, which is also called store-and-forward telemedicine, involves monitoring and delivering feedback via email, Internet, automated messaging systems, cell phone, or other forms of data transmission for assessment at a convenient time.

Health Optimum, which was launched in 2004, is a telemedicine project that was approved and cofunded by the European Community within the eTEN program.[7] The objective of the project was to investigate if telemedicine can deliver health care across distances within regions of Italy (Veneto), Spain (Aragon), and Denmark (Funen), respectively, and if it is to the benefit of the patient and the health care system. As a result of the Health Optimum project, patients with diabetes living on the island of Aeroe in Denmark are offered expert diabetes care that they could otherwise receive only at Odense University Hospital, Svendborg, on the mainland. The telemedicine solution takes advantage of both synchronous and asynchronous interactions. In addition, the set-up offers a way of redistributing workload between physicians and nurses.

This retrospective study from 2005 to 2012 examines the impact of the present telemedicine service on essential parameters compared with conventional outpatient control. As a comparator, we use data from the 2011 Danish National Diabetes Registry (DVDD) annual report comprising adult patients with diabetes attending outpatient clinics in Denmark.[8] Moreover, we provide estimates for cost-effectiveness and patient satisfaction.

Methods

Material

Study participants were patients with diabetes living on the island of Aeroe who were referred by the general practitioner or patients living on Aeroe but previously controlled at the hospital on the mainland (**Figure 1**). Inclusion criteria for

the present study were at least 6 months of telemedicine control, with a minimum of two visits and two hemoglobin A1c (HbA1c) values. The time point for collection of demographic, anthropometric, and metabolic variables as well as employment status was set to be either the last consultation before termination of telemedicine control or the last consultation before July 1, 2012, for subjects continuing in the telemedicine outpatient clinic. The last measured value of HbA1c before transition to telemedicine consultations was used as a comparator.

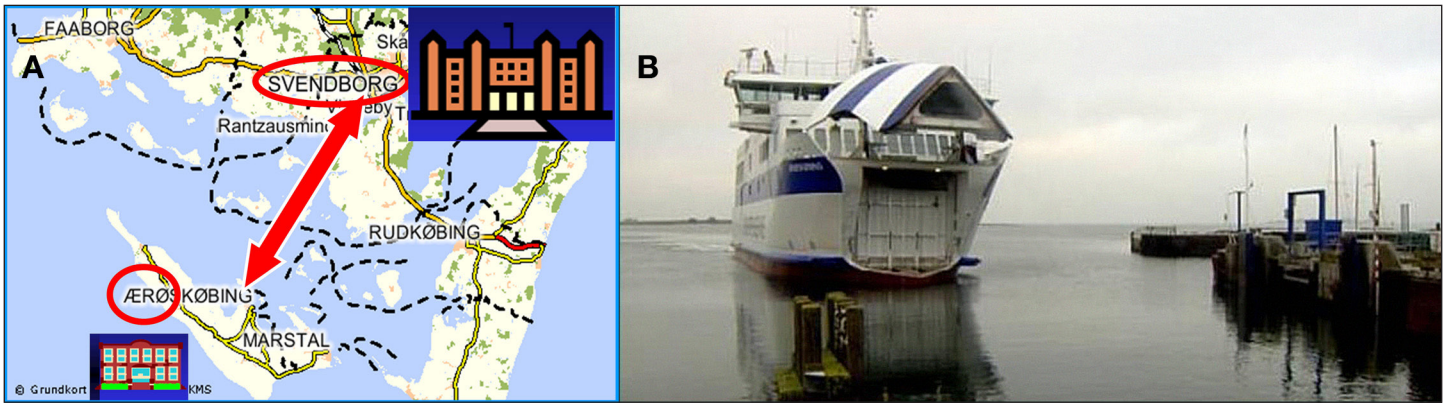

Figure 1. Description of Aeroe and means of transportation. **(A)** Aeroe: ~7000 inhabitants, 25% > 65 years old, estimated 300 patients with diabetes (T1DM and T2DM). **(B)** Before telemedicine service: Transportation time by ferry to Svendborg 1.5 h each way, transfer from harbor to main hospital, waiting time until ferry returns to Aeroe.

Design

Telemedical diabetes consultations were conducted with the patient and nurse specialist placed in a diabetes consultation room of Aeroe Hospital. If needed, both could be in audiovisual contact with the physician situated in his office at the hospital in Svendborg. An adjustable video camera with zoom function was controlled by the physician (Vcon Videoconferencing Systems; **Figure 2**).

Consultations were scheduled at 30 min intervals from 9:00 AM to 2:30 PM. Depending on their individual needs, 9 to 12 patients were evaluated during this period with respect to standard diabetes parameters, including the level of glycemic control, risk of hypoglycemia, blood pressure, weight, albuminuria, and foot examination, and laboratory parameters such as HbA1c, creatinine, and lipids. The timeframe also allowed for education in the use of glucose meters and initiation of insulin or glucagon-like peptide-1 treatment. Audiovisual contact was established if the nurse specialist or the physician found it appropriate or if the patient wanted to consult with the physician. Contact with the physician was always established at the first visit of a patient to the telemedicine set-up or if an adjustment in medicine (except insulin) was needed. On average, the physician was in audiovisual contact with 80% of the patients per consultation. After the consultation, either the nurse specialist or the physician or both made a note to the electronic patient record. Receipts were transmitted online to the pharmacy via the electronic patient record. The nurse specialist visited the island one day every second week, and each patient was, as in the conventional outpatient clinic, controlled 2–4 times per year, depending on the level of glycemic control and the degree of comorbidities.

The consultation takes advantage of a quality-monitoring diabetes database, Dialog, which provides the caregiver with a quick overview of the essential parameters for the patient[9] (**Figure 3**). Dialog automatically captures all laboratory parameters and the grading from retinal photos, whereas anthropometric data, blood pressure, foot examination, episodes of severe hypoglycemia, and cardiovascular events are entered manually. All historical data can be seen. Moreover, Dialog has online access, thereby allowing patients to see, but not edit, their own data via the National Danish eHealth Portal.

Statistics

The DVDD is a national diabetes database that monitors the quality of diabetes treatment in all adult patients treated at hospital outpatient clinics in Denmark.[8] Reports are generated on a yearly basis. Only data from patients with known

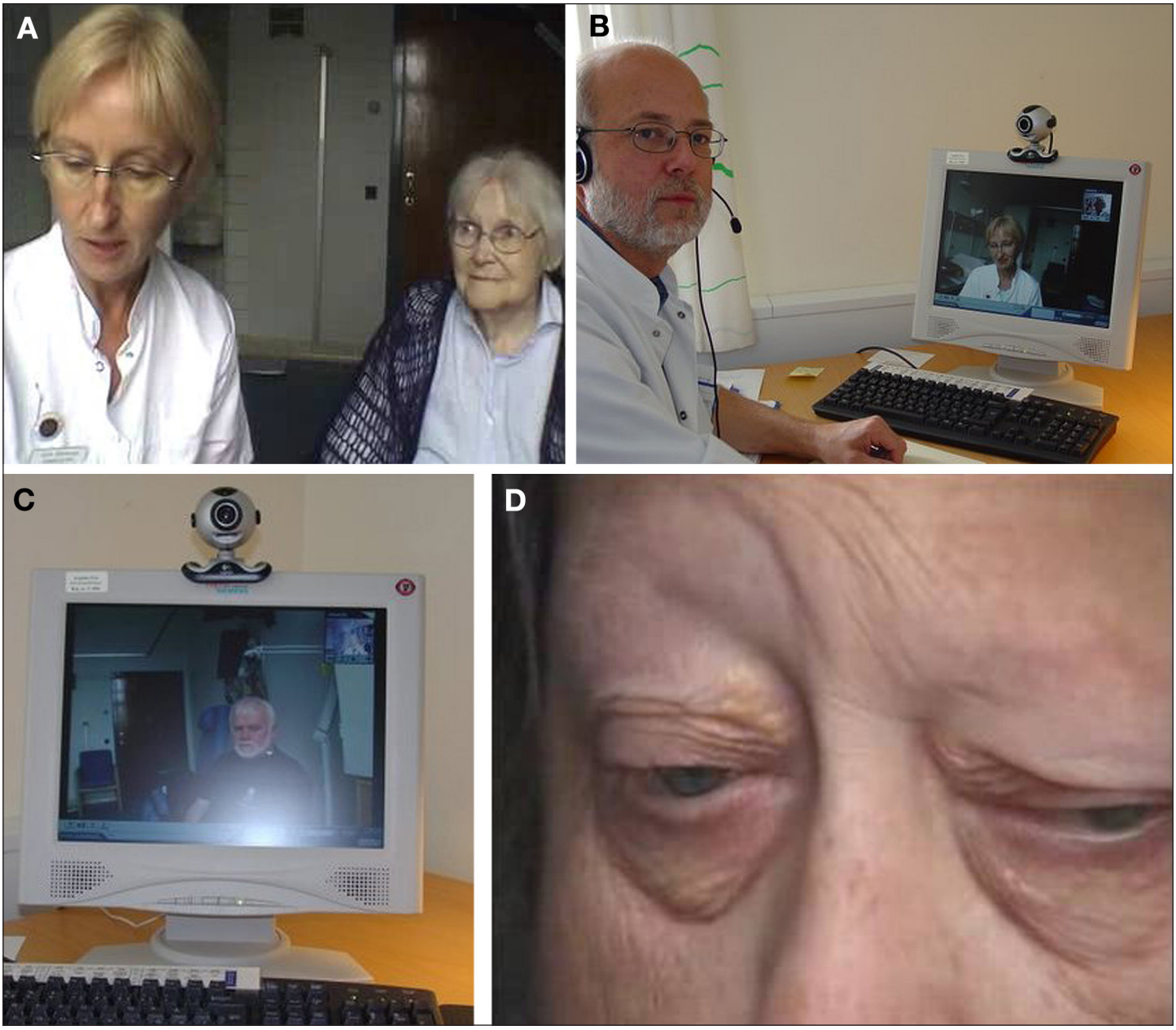

Figure 2. Use of audiovisual equipment during teleconsultation: **(A)** nurse (Jette Madsen)–patient consultation, **(B)** physician (Joergen Hangaard)–nurse contact, **(C)** patient–physician consultation, and **(D)** zoom function directed by the physician.

diabetes for more than a year can be reported to the DVDD. The present 2011 report is from the period March 1, 2011, to February 29, 2012, and comprises data from 37,567 patients controlled in hospital outpatient clinics. Of the 37,567 patients, 16,034 had T1DM and 20.856 had T2DM, whereas 677 patients are reported with unknown (4) or other forms (673) of diabetes. Only patients classified as either T1DM or T2DM were included in the statistical analysis. Sample medians were tested against DVDD medians using the Wilcoxon signed rank test, and confidence intervals were estimated using nonparametric bootstrapping methods (1000 repetitions with replacement). Stata 11.2 was used as statistical software in all analyses.

Results

In total, 81 patients living on Aeroe have followed the telemedicine service in this 7-year period, beginning with the project start in July 2005. Two patients could not be included in the present analysis due to less than 6 months of

Figure 3. Dialog, a Web-based quality-monitoring diabetes database with logon possibility for patients to their own data. Bottom left: automatic capture of laboratory data. Upper right: automatic capture of description from retinal photo.

follow-up, 1 patient had less than two visits, and 1 patient underwent gastric bypass surgery, resulting in normalization of glucose metabolism. Of the remaining 78 patients, 23 had T1DM and 55 had T2DM. One patient with secondary diabetes due to chronic pancreatitis has been allocated to the T2DM group. Average time of control was 58 and 54 months for T1DM and T2DM patients, respectively. The T1DM patients were significantly older compared with the DVDD-population, reflecting that the population on Aeroe, in general, is older. Seventy percent of the T2DM patients were on insulin treatment.

During telemedicine control, HbA1c decreased in both groups. In the T2DM group, this was most likely due to initiation of insulin treatment. Nevertheless, the reduction resulted in a slightly lower HbA1c level of 7.4% (57 mmol/mol) compared with 7.6% (60 mmol/mol) in the DVDD population, ($p < .05$). Patients with T1DM achieved a similar glycemic control compared to DVDD, despite the patients being significantly older. In the T1DM group, two patients had initially very high HbA1c values due to recently diagnosed diabetes. There were no differences in blood pressure and lipid values compared to DVDD.

All patient characteristics are given in **Table 1**.

Patient Satisfaction

Due to a lack of a predefined control group, the present study does not allow for a specific measurement of patient satisfaction. However, many of the patients, especially in the T1DM group, were previously controlled at the hospital on the mainland and can therefore be taken as a surrogate marker of patient satisfaction. In general, these patients found the telemedicine solution to be a significant improvement compared with traditional care. This was also the case for

Table 1.
Patient Characteristics and Clinical Outcomes after Telemedicine Intervention[a]

	T1DM		T2DM	
	Aeroe	DVDD	Aeroe	DVDD
Months in telemedical control	58 (45.2–70.8)	—	54 (39.6– 68.4)	—
Age (years)	65 (56–74)[b]	49	67 (64–70)	65
Duration of diabetes (years)	21.0 (10.7–31.3)	20.5	14 (10.5–17.5)	11.7
Body mass index (kg/m^2)	26.4 (24.3–28.5)	25.1	31.0 (27.7–34.3)	30.7
HbA1c before telemedicine (%, mmol/mol)	8.7 (8.2–9.2)[b] 72 (66–77)	7.9 (63)	7.9 (7.5–8.4) 63 (58–68)	7.6 (60)
HbA1c after telemedicine (%, mmol/mol)	8.0 (7.4–8.6) 64 (57–71)		7.4 (7.1–7.7)[b] 57 (54–61)	
Systolic blood pressure (mmHg)	130 (125–135)	130	130 (129–131)	133
Diastolic blood pressure (mmHg)	80 (72–88)	78	80 (78–82)	78
Total cholesterol (mmol/liter)	4.6 (4.1–5.1)	4.5	4.1 (3.8–4.4)	4.1
Low-density lipoprotein cholesterol (mmol/liter)	2.2 (2.0–2.4)	2.3	2.0 (1.8–2.3)	2.0
High-density lipoprotein cholesterol (mmol/liter)	1.9 (1.6–2.2)	1.6	1.2 (1.1–1.3)	1.1
Triglyceride	0.9 (0.7–1.2)	0.9	1.7 (1.3–2.2)	1.6

[a] Data are given in medians.
[b] $p < .05$ compared with the DVDD.

the elderly patients who quickly got accustomed to audiovisual communication with the physician. Patient satisfaction was primarily related to the major reduction in transportation time, which amounts to a full working day. Attendance to telemedicine control was approximately 90%, which was comparable with conventional outpatient control.

Cost-Effectiveness

Cost-effectiveness of the telemedicine solution can be divided into (1) immediate and well-defined costs and savings and (2) less well-defined economical benefits due to a positive impact on either the health care system and/or business productivity.

The immediate cost reduction is primarily related to the absence of transportation costs and was estimated to be 350–400 Danish kroner (dkr; $60–70) per patient per visit. Thus, beforehand, patients themselves or the National Health Insurance System had expenditures for ferry tickets and for taxi fare to take elderly patients to and from the main hospital in Svendborg. With approximately 200 telemedicine consultations per year, the yearly reductions in traveling expenses add up to 70,000–80,000 dkr ($12,175-13,900). By subtracting the yearly costs of the system (**Table 2**), the net cost reduction with the telemedicine solution can be estimated to be 54,230–64,230 dkr ($9,430–11,170).

Approximately 30% of the patients attending telemedicine control had a full-time job. If these patients were to visit the outpatient clinic on the mainland, it would cost them an entire day off from work. However, using the telemedicine solution, their absence from work could be reduced to approximately 1 h. Traditionally, employers have accepted to pay one sick-leave day for a health condition. Nevertheless, the employer will suffer a productivity loss corresponding to at least the salary of the employee, and with an average yearly salary of

Table 2.
Cost of Technical Solution[a]

Hardware and software Installation	33,000 dkr ($5740) 20,000 dkr ($3480)
Service per year	5,000 dkr ($870)
Transportation of nurse specialist from Svendborg to Aeroe per year	3,200 dkr ($560)

[a] Costs are given in 2011 prices. Conversion rate $1 = 5.75 dkr

322,493 dkr ($56,100),[10] the productivity loss can be estimated as 322,493 dkr/220 working days = 1466 dkr ($255) per day. It should be noted that this calculation does not take into account the possible costs of the short absence from work with the telemedicine set-up.

In the conventional outpatient clinic in Svendborg, the nurse specialists and physicians control the patients at separate days with consultations scheduled for 30 and 20 min, respectively. Using telemedicine diabetes consultations, the average time used by the nurse specialist was still 30 min, whereas the physician, on average, used 5–10 min per patient per consultation, which, in addition to direct patient contact, also included updating medication lists, sending receipts, and referring patients to other departments. Importantly, real-time communication between nurse specialist and physician allowed for unresolved issues to be dealt with immediately as compared with the conventional outpatient clinic in which the separate nurse specialist consultations often resulted in subsequent physician paperwork and nurse-specialist–physician consultation. Thus, the present telemedicine solution results in a redistribution of workload between physician and nurse specialist.

Discussion

The chronic nature of diabetes combined with the ongoing need to empower patients make the disease an "ideal" context to test information and communication systems as a means to support care and as possible instruments to reduce the increasing economic burden of diabetes on the health care system. In the present study using audiovisual teleconsultation, we clearly demonstrate the feasibility of a telemedicine solution by achieving similar results on essential diabetes treatment parameters and, in the T2DM group, even a slightly lower HbA1c value. Compared with conventional care, the telemedicine set-up on the island of Aeroe was also found to be economically beneficial and associated with greater patient satisfaction.

Several studies have documented the importance of improved glycemic control in reducing microvascular complications in T1DM and microvascular and macrovascular complications in T2DM subjects,[11,12] yet subsequent studies in T2DM subjects raised some concerns leading to a more cautious and individualized approach.[13] The average age of the T1DM subjects in the present study was much higher compared with the DVDD. Bearing this in mind, the attained HbA1c level of 8.0% seems acceptable, in particular, because the majority of patients were living alone. In the T2DM group, the reduction in median HbA1c reached statistical significance compared with the DVDD. A possible explanation for this could be that the present ICT system, in fact, facilitates communication between the nurse specialist, the patient, and the physician compared with the regular outpatient clinic.

Numerous studies in a variety of settings have investigated the effect of ICT in diabetes management, and although many of these studies could demonstrate telemedicine to be both feasible and reliable, they often lack a more precise insight into its potential clinical effectiveness.[4–6,14] Simultaneously implementing and evaluating a telemedicine solution can, however, be a difficult task notwithstanding the establishment of a control group. As noted by Friedman and Wyatt,[15] a telemedicine intervention cannot be compared to a classical drug intervention, as it has an impact on both patients and caregivers. Furthermore, in the field of telemedicine, where technology is rapidly evolving, the time course of a longitudinal study may be greater than the lifetime of the original technology, as shown in the IDEATel study.[16]

Diabetes treatment in Denmark is well organized and, to a great extent, is covered by the public sector. In reality, this means that there are no underserved areas with poor access to services, and our primary aim was therefore not to show an improvement in specific diabetes parameters, but to investigate whether the results generated with the present telemedicine solution were in accordance with standards of care. In that respect, we had the advantage of already having a control group not using telemedicine, namely, the DVDD, which, due to the number of patients, undoubtedly represents the clinical standards of diabetes care related to hospital outpatient clinics in Denmark.[8] In the IDEATel study, HbA1c in the intervention group at year 5 was 0.29% lower, and small improvements in blood pressure and cholesterol levels were also seen.[16] The design of the IDEATel study was, however, quite different compared with our study in that the target population was living in medically underserved areas and participants in the intervention group were equipped with a home telemedicine unit used for counseling by a nurse case manager. Moreover, the

primary care physicians of intervention patients retained full responsibility and control over their patients but could be contacted by the nurse case manager if he or she believed a change in management was indicated. Despite the size and duration, the IDEATel study lacked the statistical power to assess potential effects on mortality and/or clinical events such as macrovascular complications. In contrast, the telehealth intervention in the Whole System Demonstrator cluster randomized trial demonstrated a reduction in mortality and emergency admission rates in a mixed group of patients with diabetes, chronic obstructive pulmonary disease, and heart failure.[17] Subgroup analysis has yet to be performed; however, it has previously been suggested that these favorable effects were more consistent in pulmonary and cardiac disorders.[18]

The present study is a retrospective study with no predefined control group and, therefore, we could not use a validated measure of patient satisfaction with our telemedicine diabetes service as compared with the IDEATel study.[16] Although this, in theory, might be a limitation of the study, all patients consistently, either by questioning or spontaneously, expressed their satisfaction with the major reduction in transportation time associated with present telemedicine solution.

To our knowledge, the present ICT solution for telemedicine diabetes management has not been tested in any setting before. In that respect, it could be argued that it is not a "true" telemedicine solution because a nurse specialist is situated in the same room as the patient. Nevertheless, our set-up offers several advantages—by having a nurse specialist with the patient, a complete diabetes program can be conducted including, for example, initiation of insulin treatment and a foot examination. The patients can participate regardless of severe comorbid conditions, and patients with barriers to computer software can be assisted by the nurse specialist in establishing audiovisual contact with the physician. Regarding the latter aspect, we note that the IDEATel study had a significantly higher drop out rate in the intervention group partly due to difficulty or frustration with the home telemedicine unit.[16] However, one must assume that, today, the expensive home telemedicine unit[19] could possibly have been replaced with less costly smartphones, iPads, or laptop devices owned and maintained by the patients, provided that a secure data management infrastructure between patient and health care personnel can be guaranteed.

In the economic analysis of the present telemedicine set-up, two factors seem particularly relevant. The first and most straightforward is the reduction in transportation costs, whereas the increase in productivity due to a reduction in work absences is more difficult to evaluate.[19–21] However, using an average income from the National Danish Statistical Bureau,[10] we have provided a rough estimate of the loss of productivity if the full-time working patient had not been followed in the telemedicine set-up. A 6-month study in T1DM subjects using a telemedicine-supported software system for individualized insulin dose adjustments could show the same beneficial effects on travel costs and working days,[22] which also was the case in a nonrandomized 6-month study from Northern Norway using satellite outpatient clinics.[23] These researchers also included the value of lost leisure time, which may not be appropriate.[21] Nevertheless, cost-effectiveness was retained even after omitting this from the analysis. In the present study, the redistribution of workload between nurse specialist and physician is probably cost neutral in absolute terms, as the 50% increased workload of the nurse specialist is offset by the approximate 25% reduction in the more expensive physician workload. This balance may, however, turn out favorable for the health care system in situations where shortage of physicians is predominant.

When performing an economic evaluation of a telemedicine solution, the distinction of costs incurred within or outside the health care system is necessary. In the present study, the stakeholders experiencing the benefits were the patients, employers, and the national insurance system that covers traveling expenses, whereas the health care system had expenditures related to the ICT system and the traveling of the nurse specialist. Importantly, our telemedicine set-up with a nurse specialist placed in the same room as the patient secured a "normal" reimbursement of the consultation as opposed to other telemedicine settings where implementation is often hindered by inadequate compensation.[4]

Conclusion

The present telemedical solution using audiovisual consultation as a means to communicate with both patient and nurse specialist is feasible, and the interdisciplinary intervention achieved good adherence, patient education, and

high treatment quality evaluated by essential diabetes parameters. We also demonstrate a reduction in costs. However, it should be emphasized that the health care system does not necessarily stand to save money from ICT systems, and therefore cost analyses of telemedicine solutions can only be performed at the society level.

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Co-authors Jette Madsen and Joergen Hangaard and their patients gave permission for their images to be used in Figure 2.

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