Using Telecare for Diabetic Patients:
A Mixed Systematic Review

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***Abstract*—Numerous telecare interventions and technologies are used in the management of type 2 diabetes mellitus. This systematic review examines the different telecare interventions implemented, the technologies used, as well as their associated outcomes. Such a synthesis aims at optimizing telecare use for diabetic patients and informing decision makers on technology selection and the impacts that can be expected with telecare use. Following a systematic, comprehensive search of databases, 2,139 qualitative and quantitative studies were initially selected; after careful review and screening, 50 studies were coded and analyzed. The results of this review will be used by healthcare professionals, organizations and patient support groups to tailor their policies with regards to the choice, planning, diffusion and monitoring of telecare interventions and the technologies implemented to care for patients with diabetes.**

Keywords- telecare; health information technology; diabetes, systematic review; mixed methods

I. INTRODUCTION

The use of telecare technologies (TT) seems to hold promise for chronic care management since it "produces accurate and reliable data, empowers patients, influences their attitudes and behaviors, and potentially improves their medical conditions [1]." However, there is still a lack of evidence on its clinical effects, cost effectiveness, and impacts on service utilization [1]. The large prevalence of type 2 diabetes mellitus (T2DM) in the patient population and the impetus for quality of care—including monitoring, self-care and close follow-up—are creating a need for the development and use of TT. However, given the large variety of TT currently available and the diversity of interventions, ranging from condition monitoring to instant health diagnoses, it is difficult to fully grasp the actual impacts of telecare. There have been numerous reports of interventions designed to improve the care of patients with diabetes, but their effectiveness is unclear. It is now essential to assess the overall effectiveness and efficacy of telecare in the care of patients with T2DM and to verify whether all TT are beneficial. There is also a need to assess the impact of telecare on adherence to guidelines, enhanced monitoring, fewer treatment errors, and a reduction of overall health care system costs for patients with T2DM. This paper therefore presents an ongoing mixed systematic review of telecare interventions and the technologies used in diabetic care. The specific objectives of this review are: (1) to provide a typology of the different telecare interventions and technologies used and (2) to determine the outcomes, both positive and negative, of telecare used in the context of T2DM.

II. METHODS

A mixed-method systematic review was used to integrate results from both qualitative and quantitative studies [2]. Through a review of evidence from both qualitative and quantitative studies, disparate data were synthesized in order to better understand complex phenomena such as the adoption of innovations [2-5]. This mixed review followed recognized standards for systematic reviews [6,7] and is presented according to PRISMA criteria [14]: (1) eligibility criteria; (2) information source and search strategy; (3) study selection; (4) data collection process and synthesis of results; and (5) critical appraisal.

The studies that met the inclusion criteria were evaluation studies using a quantitative, qualitative or mixed-method study design. We did not *a priori* exclude specific study designs, but quantitative and/or qualitative results had to be available. The review considered all types of telecare interventions, including telemonitoring, telediagnosis, teleconsultation and all types of technologies, including internet and smart phone use. Articles were excluded if they focused solely on describing a telecare intervention or a technology.

The review is based on a systematic, comprehensive search of six databases: Medline, Embase, Cochrane, ISI Web of Science, CINAHL, and Scopus. It considered articles in English or French, published or in press between January 2000 and March 2011. The literature search was performed by a librarian and validated by a researcher. The following sets of keywords and terms were searched in combination: Telecare Technologies: (Telemedicine/, Telehealth/, tele*, mobile health, m?health; remote adj (consult* or monitor* or health), video?conferenc*, e?Health, phone?) and Diabetes: (Diabetes Mellitus, Type 2/, Non insulin dependent diabetes mellitus/, Diabetes Mellitus, Non-Insulin-

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Dependent, diabet* or MODY OR NIDDM OR T2DM OR IDDM). We hand-searched the reference lists of all the selected references. EndNote software was used to manage the references and eliminate duplications.

Studies were independently selected by two researchers. First, references were selected based on title and abstract according to the review study's inclusion and exclusion criteria. When there was any doubt, the study was provisionally included for consideration on the basis of a reading of the full text. The second round of selection was based on the full texts of the papers. Any disagreement was resolved through consensus. In a few cases, disagreements were arbitrated by two other researchers; a study was included only when these two researchers agreed that the study was eligible. Kappa scores were calculated at each stage.

Data extraction from the selected studies was performed independently by two researchers using a standardized form that included: nature of the telecare intervention, technology characteristics, country, year, author, type of study (quantitative, qualitative or mixed), study design, type of participants, region (rural/urban), and all outcomes. The impacts of telecare on each outcome were coded narratively (positive impact, negative impact, no impact, not reported). Once again, any outstanding disagreement on data extraction was resolved through consensus by two other researchers.

We first conducted a narrative synthesis of the studies [8,9] using the validated methodological guide for narrative syntheses in order to ensure that the synthesis would be transparent and reproducible [8,9]. The narrative synthesis was performed by two of the researchers and validated by two others. This allowed us, first, to develop a typology of telecare by creating homogeneous sub-groups of telecare interventions and technologies that go beyond their denomination by the study's author, and second, to narratively analyze the results for each outcome. We grouped them into several categories: health outcomes, other patients' outcomes, quality of care, health service use-cost-productivity and satisfaction.

The methodological quality of the studies was assessed independently by two researchers. As the methods of the included studies were disparate—qualitative, quantitative or mixed—, we used all nine of the criteria from a quality assessment tool developed for systematic reviews of disparate data [10]. Any discrepancies were resolved through consensus.

III. PRELIMINARY RESULTS

The primary search yielded 2,133 references. Another 6 references were found by searching the reference lists of the retrieved articles [11]. Applying the inclusion and exclusion criteria, 1,945 references were excluded on the basis of the title and abstract (Kappa: 0.89) and 144 more were excluded on the basis of the full text (Kappa: 0.93). The final sample consisted of 50 articles.

A. Characteristics of the Selected Studies[1]

Twenty-five studies were conducted in North America: USA (23 studies) and Canada (2). The remaining studies were conducted in Asia (15) and Europe (7). In addition, three studies were conducted in multiple countries. The studies used quantitative designs (41), including randomized controlled trials (27), non-randomized controlled trials (5), before-after designs (6), time series (1); qualitative designs (1), or mixed-method designs (8). The studies involved solely patients (35), solely healthcare professionals (2) or a combination of patients and professionals (13).

B. Typology of telecare interventions and technologies

With regard to the nature of the telecare interventions, the synthesis of the literature revealed 23 articles on simple telecare interventions. Telemonitoring represented the vast majority of this group (17 studies). In addition, 27 articles referred to complex telecare interventions. Complex interventions were mainly a combination of telemonitoring with telediagnosis/consultation (10 studies) or with e-learning (10 studies).

C. Technologies used

With regard to the technology used, half of the studies used a single technology (25 studies). The two most used TT used on its own were distant direct transmission (9 studies) and smart phone/personal digital assistant (PDA) (7 studies). The other technologies used in isolation were: teleconference, website/internet and pager. The other half of the studies were on multiple technologies used in combination, mainly a combination of smart phone/PDA and web site/internet (11 studies).

TABLE 1: TYPOLOGY OF TELECARE INTERVENTIONS AND TECHNOLOGIES USED IN DIABETIC CARE (N=50)

Nature of telecare interventions	Number of articles
Simple interventions	**23**
Telemonitoring	17
Telediagnosis/consultation	4
E-learning	2
Complex interventions	**27**
Telemonitoring + Telediagnosis/consultation	10
Telemonitoring + e-learning	10
Other	7

[1] References available upon request.

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Telecare technologies used	
Single technology	**25**
Direct transmission	9
Smart phone or PDA	7
Teleconference (phone or video)	4
Web site – internet	4
Pager	1
Multiple technologies	**25**
Direct transmission + Web site/internet	4
Direct transmission + Teleconference + Web site/internet	6
Smart phone/PDA + Web site/internet	11
Other	4

PDA: personal digital assistant

D. Outcomes of telecare

A variety of outcomes were studied (Table 2). We grouped them according to five categories: health outcomes, other patients' outcomes, quality of care, health service use-cost-productivity and satisfaction (clinicians' and patients'). Generally speaking, telecare produces positive results for most of the outcomes.

TABLE 2: SUMMARY OF THE OUTCOMES OF TELECARE (N= 50 STUDIES)

Outcome Category	Outcome Type	N*	+	-	Ø
Health outcomes					
Specific indicators	Impact on glucose or HbA1c blood level	38	34	0	4
	Hyper or hypo glycemic events	4	2	0	2
Other health indicators	BMI or weight	13	5	0	8
	Cholesterol or triglyceride blood level	8	1	0	7
	Blood pressure	6	1	0	5
	Quality of life	7	4	0	3
	Self-perceived health	2	2	0	0
	Physical activity	5	5	0	0
	Framingham risk score	1	1	0	0
	Depression/mental health	3	3	0	0
	Nutrition intake	2	2	0	0
	Pain	2	2	0	0
Other patients' outcomes	Patients' knowledge or self-care	8	8	0	0
	Patient transfer or travel time	2	2	0	0
	Social support/functioning	4	4	0	0
	Patient worry	1	0	0	1
Quality of care	Adherence to best practice guidelines	18	15	0	3
	Accessibility to health services	2	2	0	0
	Dose of insulin used	1	1	0	0
Satisfaction	Patient satisfaction	16	14	2	0
	Professional satisfaction	5	5	0	0
Health service use-cost-productivity	Health service use	6	5	0	1
	Healthcare costs	2	2	0	0
	Time spent by clinicians	4	4	0	0

N*: Number of studies for which the outcome type was evaluated. BMI: Body Mass Index

E. Critical appraisal

Our critical appraisal reveals that their abstracts, introductions and aims were generally well written (coded as good or fair in all cases). The research methods used were robust most of the time. However, weaknesses were observed in the descriptions of the methods, particularly in terms of a lack of detailed information on the data collected, on the sampling methods used and the data analysis. Despite these weaknesses, the critical appraisal indicates that the extant research findings and results are credible and generalizable; these results typically have practical implications. A sensitivity analysis [6] was conducted to determine whether the decision to include all the studies, independent of their overall quality, had any effect on the results of the review. Even when we excluded the only article with at least one bad quality indicator, the findings of this review remain robust.

IV. DISCUSSION AND CONCLUSION

Considering the great variety of telecare interventions and technologies and the fact that each outcome is poorly understood, this article clarifies the nature of the different telecare interventions implemented, the technologies used per se, and the associated outcomes. The most common telecare interventions are remote monitoring, which is sometimes combined with other types of interventions such as telediagnosis/consultation or e-learning. These interventions are enabled by a variety of technologies. Half of the interventions reported the use of a single technology (mainly direct transmission), while the others reported use of a mix of technologies.

Based on our preliminary results, our systematic review reveals that, overall, the use of telecare has positive outcomes such as improved health status, increased quality of care, decreased health service use or cost, increased satisfaction and increased patient knowledge. In particular, the use of TT to monitor patients with diabetes allows for more flexibility and more frequent monitoring. In their 12-month study of veterans with diabetes, Chumbler et al [12] found that the

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number of admissions and bed days of care decreased by half in the group receiving less intensive but daily monitoring, whereas it doubled in the more intensive monitoring group. They suggest that "less intensive assessments have a greater effect on reducing service use than less frequent but more intensive evaluations" (p.155). From this perspective, our review shows that telecare improves chronic disease management for patients with diabetes and may play a critical role in delivering appropriate individualized and flexible care for patients with diabetes. Telecare is thus a promising solution in the current search for patient-centered care [13]. It has been shown that interventions targeting healthcare professionals, such as clinical and organizational interventions that facilitate structured and regular reviews of patients, are effective in improving the process of care [14]. Also, interventions targeting the patients themselves, such as educational and behavioral interventions, produce better diabetes self-management and patient outcomes [15].

On the other hand, our typology highlighted the variety of telecare interventions and technologies currently used to improve clinical processes and patient outcomes. Our results suggest that no given intervention or technology is clearly superior. Research results indicate that there is no "one size fits all" solution. Healthcare clinicians and managers need to carefully select the type of TT that will be most appropriate, based on the needs of their organizations and clienteles.

Our results may serve to identify the characteristics and impacts of telecare, optimize telecare use, and inform decision makers on telecare interventions and technology selection and the impacts they can expect from telecare use.

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