# Telemedicine in the Management of Type 2 Diabetes Mellitus

Guixia Wang, MD, PhD, Zhengyun Zhang, MD, PhD, Yakun Feng, MD,
Lin Sun, MD, Xianchao Xiao, MD, PhD, Gang Wang, MD, Yuan Gao, MD,
Huan Wang, MD, Hong Zhang, MD, Yufeng Deng, MD and
Chenglin Sun, MD, PhD

CrossMark

## ABSTRACT

**Objective:** To explore a model of Internet-based integrated management of diabetes, we established a remote diabetes medical service platform (U-Healthcare) and evaluated its effectiveness and practicality.

**Materials and Methods:** In total, 212 patients with type 2 diabetes mellitus were randomly assigned to 2 groups. Data from the intervention group were automatically transmitted through a glucometer; furthermore, this group received information regarding medicines, diet, exercise and other management through U-Healthcare. The control group received conventional medical treatment without any additional intervention. All patients were regularly followed up every 3 months for half a year.

**Results:** At the 3-month follow-up, fasting plasma glucose levels of the intervention group were significantly lower than those at the baseline as well as those of the control group. Triglyceride levels of the intervention group were much lower than those at the baseline. At the 6-month follow-up, 2-hour postprandial plasma glucose levels of the intervention group significantly improved compared with those of the control group. HbA1c levels gradually decreased every 3 months in the intervention group, and the mean change in the levels was significantly greater in this group than in the control group (from 1.27-0.68%). At the end of the study, more than 80% of the patients in the intervention group adhered to blood glucose monitoring 2-3 days per week, and their compliance degree was 72%.

**Conclusions:** The Internet-based U-Healthcare system of integrated management in diabetes not only achieved better glycemic control, effectively improved HbA1c levels and decreased triglyceride levels but also enhanced patients' adherence to the medical team's instructions.

**Key Indexing Terms:** Diabetes; Telemedicine; U-Healthcare. **[Am J Med Sci 2017;353(1):1–5.]**

## INTRODUCTION

As announced by the International Diabetes Federation, the current number of 382 million people affected by diabetes globally is expected to increase to 592 million by 2035.[1] A nationwide epidemiological survey by the China Diabetes Society between 2007 and 2008 reported a 9.7% morbidity rate of diabetes among Chinese people aged above 20 years and a total number of 92.4 million adult patients.[2] Current insufficiency in medical resources for unbiased, regular and real-time blood glucose management has financially burdened the patients and failed to effectively control the development and progression of diabetic complications.[3] An Internet-based telemedicine service platform that allows real-time collection of the patients' medical information and timely delivery of the medical team's advice on medication, diet and exercise, etc. is urged for helping the patients with self-management and for improving patient compliance.

In recent years, Ubiquitous Health Management System (U-Healthcare), a novel healthcare mode for patients with chronic diseases like diabetes and hypertension has emerged. Incorporating IT in healthcare, U-Healthcare allows ubiquitous use of health management and medical service systems based on wired or wireless networks.[4] It monitors biological signals and health information through a biomonitor, and transmits data (blood glucose, blood pressure and calories) through the wired or wireless network to hospitals and medical centers.[5] The medical team can promptly analyze the data and provide feedback to the patients.[6] This system offers remote patient management that allows the patients to, based on the medical information provided by the medical center, realize self-management of diet and exercise under the guidance of the medical team. The use of a U-Healthcare system may also spread beyond patients suffering from chronic disease to subhealthy or healthy people who need health management.

Medical resources in rural areas of China are less developed and lack not only large hospitals, but also experienced physicians. Therefore, the spread of high-level medical services to rural areas by means of the Internet is probably an effective method to solve the contradiction between supply and demand for rural medical services. In China, previous U-Healthcare studies were all targeted to regions within the coverage of high-level medical services and urban patients

with high levels of education. However, there has not been any U-Healthcare studies in underdeveloped regions such as rural areas. It is unclear whether the U-Healthcare services of modern times could be applied to underdeveloped rural areas, and could effectively improve the conditions of patients with diabetes.

In this study, efficacy and applicability of a U-Healthcare diabetes telemedicine platform were evaluated in a randomized control trial by building an Internet-based, integrated diabetes management system.

## SUBJECTS AND METHODS

### Subjects

Subjects were screened from rural patients who presented to the Department of Endocrinology and Metabolic Diseases, First Hospital of Jilin University, had access to the Internet at home and were able to participate in this randomized and controlled study. Inclusion criteria were type 2 diabetes mellitus (T2DM), diabetes confirmed for more than 1 year and HbA1c 7-10.0%. Exclusion criteria were severe internal diseases, severe diabetic complications, several renal diseases with serum creatinine >132.6 umol/L (men) or >123.8 umol/L (women), severe hepatic diseases or elevation of AST or ALT ≥ 2.5 × ULN, failure to take medications as scheduled within the 3 months prior to screening, receiving treatment with insulin pump,

currently participating in or planning to participate in another clinical trial, pregnant women and illiteracy. A total of 212 patients met inclusion criteria in the screening and were randomized into the intervention group (106 patients) and control group (106 patients). All patients included provide consent.

### Methods

Clinical study protocol for this study was approved by the Ethics Committee of the First Hospital of Jilin University. And the study was carried out in accordance with the Declaration of Helsinki.

In the intervention group, a glucometer that could automatically upload blood glucose data via a cable was dispensed to each patient for free. Patients were required to take their blood glucose at least 2 times 2-3 days per week. Data were transmitted to the database by connecting the glucometer to a computer, and information about diet, exercise, blood pressure and body weight was submitted by the patient on the U-Healthcare website. The medical team at the medical center logged onto the website every 2 weeks to analyze the patients' information including blood glucose, calorie intake and consumption, and to deliver the medical team's advice (based on 2010 China Guideline for Type 2 Diabetes Mellitus) to the patient by leaving messages on the website or via telephone to prompt and supervise the patients on blood glucose self-monitoring and compliance to a diet and exercise

**TABLE 1.** Baseline characteristics of the 2 groups.

|  | Control | Intervention | *P* Value |
|---|---|---|---|
| *n* | 106 | 106 | |
| Men/women | 52/58 | 64/46 | |
| Age (years) | 54.7 ± 10.3 | 52.6 ± 9.1 | 0.117 |
| Diabetes duration (years) | 7.7 ± 6.8 | 8.1 ± 7.6 | 0.195 |
| FPG (mmol/L) | 8.0 (6.4-10.3) | 7.9 (6.5-9.3) | 0.511 |
| HbA1c (%) | 8.0 ± 0.8 | 7.9 ± 0.7 | 0.081 |
| 2hPG (mmol/L) | 11.4 (9.9-15.0) | 12.0 (10.0-14.5) | 0.997 |
| TG (mmol/L) | 1.7 (1.1-2.5) | 2.0 (1.5-3.2) | 0.001 |
| TC (mmol/L) | 4.9 ± 1.0 | 5.1 ± 1.1 | 0.429 |
| HDL-C (mmol/L) | 1.2 ± 0.3 | 1.2 ± 0.5 | 0.298 |
| LDL-C (mmol/L) | 2.9 ± 0.8 | 2.9 ± 0.7 | 0.558 |
| BUN (mmol/L) | 5.6 (4.8-6.6) | 5.4 (4.8-6.3) | 0.404 |
| Cr (mmol/L) | 63.5 (54.7-74.9) | 65.8 (56.1-76.3) | 0.359 |
| AST (U/L) | 22.0 (19.0-26.0) | 22.0 (18.0-27.0) | 0.058 |
| ALT (U/L) | 22.8 (16.0-33.5) | 25.5 (16.0-36.0) | 0.564 |
| r-GT (U/L) | 27.0 (27.0-43.0) | 28.5 (20.0-45.5) | 0.711 |
| BMI (kg/m$^2$) | 24.9 (22.8-27.2) | 25.8 (24.0-27.8) | 0.114 |
| Systolic pressure (mm Hg) | 130.0 (120.0-140.0) | 130.0 (120.0-139.0) | 0.107 |
| Diastolic pressure (mm Hg) | 80.0 (75.0-90.0) | 84.0 (80.0-89.0) | 0.298 |

Data are mean ± SD or median (interquartile ranges).
FPG, fasting plasma glucose; HbA1c, hemoglobin A1c; 2hPG, 2-hour postprandial plasma glucose; TG, triglyceride; TC, total cholesterol; HDL-C, high density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; BUN, blood urea nitrogen; Cr, creatinine; AST, aspartate aminotransferase; ALT, alanine aminotransferase; r-GT, r-glutamyltransferase; BMI, body mass index.