



## New Directions in Chronic Disease Management

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A worldwide epidemic of chronic disease, and complications thereof, is underway, with no sign of abatement. Healthcare costs have increased tremendously, principally because of the need to treat chronic complications of non-communicable diseases including cardiovascular disease, blindness, end-stage renal disease, and amputation of extremities. Current healthcare systems fail to provide an appropriate quality of care to prevent the development of chronic complications without additional healthcare costs. A new paradigm for prevention and treatment of chronic disease and the complications thereof is urgently required. Several clinical studies have clearly shown that frequent communication between physicians and patients, based on electronic data transmission from medical devices, greatly assists in the management of chronic disease. However, for various reasons, these advantages have not translated effectively into real clinical practice. In the present review, we describe current relevant studies, and trends in the use of information technology for chronic disease management. We also discuss limitations and future directions.

**Keywords:** Ubiquitous; Healthcare; Diabetes mellitus; Quality of care

### INTRODUCTION

The incidence of chronic disease, including diabetes mellitus, hypertension, dyslipidemia, and cardiovascular disease, has increased rapidly as industrialization becomes ubiquitous [1,2]. The worldwide diabetic population is projected to increase from 366 million in 2011 to 552 million in 2030 [3]. Diabetes is already a major healthcare burden; the annual mortality is estimated to be 4.6 million [4]. In South Korea, the prevalence of diabetes among adults aged 30 years or over is about 12.4%, and the estimated number of diabetic subjects 4 million [5]. It is essential to improve medical services to ensure effective high-quality medical treatment; this obviously increases both demand and cost. Further increases in the incidence of chronic disease and accompanying complications are

inevitable unless the current system is changed. The social and economic expense of change must be accepted.

In patients with chronic diseases, prevention of various complications is generally more important than treating the disease *per se*. However, this is extraordinarily expensive. For example, the annual cost of treating diabetic complications in the United States is 45 billion US dollar (USD) [6,7]. Complications can be prevented if chronically diseased patients maintain healthy lifestyles. Thus, an ideal management system would allow remote 24-hour communication between the patient and a medical support team, to jointly plan lifestyle behavior and to monitor aspects of the disease. However, this is currently impossible.

Current healthcare systems focus on treatment-based care. A new focus on the prevention of chronic diseases is essential.

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Healthy high-risk subjects must be taught how to manage their lifestyles; they need information on diet and exercise. Current medical systems lack the resources to focus on lifestyles, being restricted in time, by place, and by cost. Diet and exercise interventions must be integrated into the daily lives of all diabetic patients. In South Korea, only 29.5% of such patients attain the target glycated hemoglobin (HbA1c) level (below 6.5%); diabetes management is thus generally unsuccessful.

Driven by such needs, various U-healthcare systems have been developed and their clinical benefits assessed [8-14]. The widely used expression “ubiquitous healthcare” (U-healthcare) combines the word “ubiquitous” (simultaneously present anytime, anywhere)” with “healthcare.” U-healthcare uses fixed or mobile networking to ensure access to healthcare or medical services anywhere, at any time. U-healthcare has attracted increasing interest; it is recognized that chronic diseases require continuous management, integrated into daily life. Such diseases cannot be efficiently managed using hospital-centered treatment methods.

### HOW CAN WE MINIMIZE THE COMPLICATIONS OF CHRONIC DISEASE AND IMPROVE THE QUALITY OF CARE?

It is essential to reduce healthcare expenditure but maintain healthcare quality. Diabetic patients are at high risk of the development of various complications and are thus in need of constant management. Diabetic complications, such as cardiovascular disease, account for the major proportion of treatment costs, which can obviously be reduced by preventing the development of complications [15]. Many reports have shown that aggressive diabetes management saves medical costs [16,17] and need not affect the quality of care. Prevention of complications, early treatment triggered by close monitoring of blood glucose levels, proactive education on diet and exercise, and regular monitoring, are all essential to manage diabetes effectively and at minimal cost. Also, detection and intensive treatment of early-stage diabetes greatly contribute to reducing the incidence and cost of long-term complications [18].

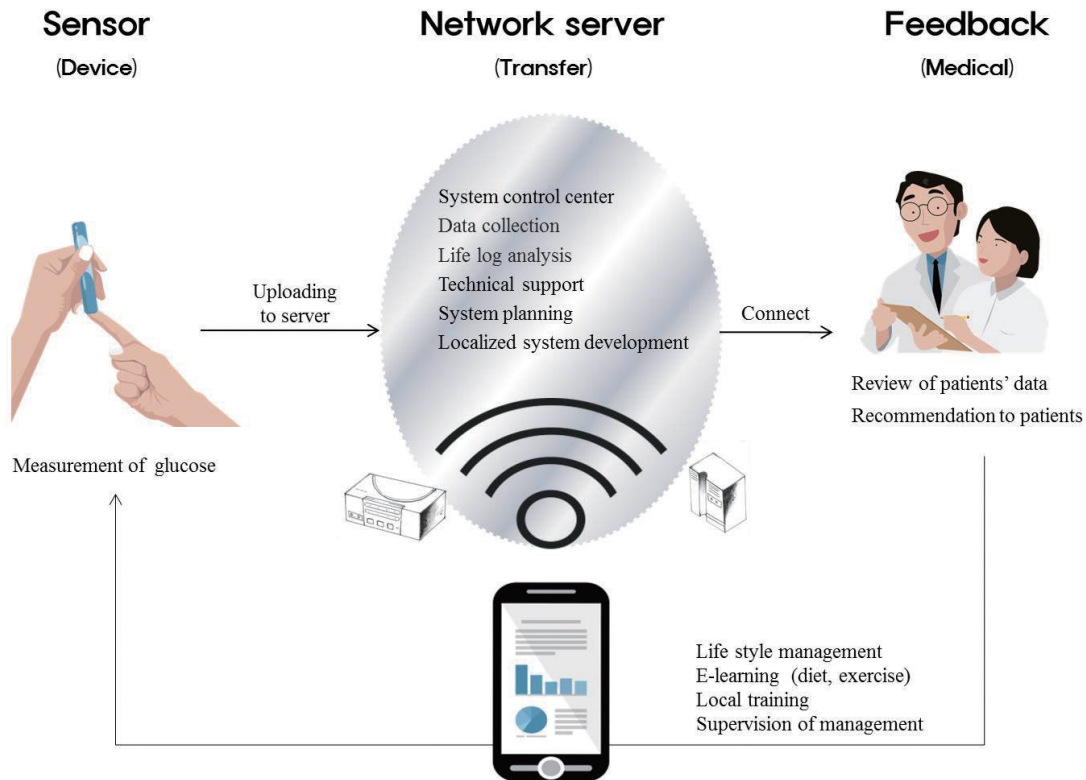
In the United States, it has been estimated that U-healthcare could save over 457 million USD annually if the model became widely accepted [19,20]. U-healthcare cannot currently replace direct consultation and treatment, but a telemonitoring or telecoaching approach to the treatment of chronic disease [21-23] such as diabetes mellitus would be very helpful for patients who have already been diagnosed and treated in hos-

pital. Regular hospital visits would continue, but health at home would be managed via telemonitoring or telecoaching using simple electronic devices. Patients remain connected to their physicians and receive medical assistance as needed. Such a system would be useful when lifestyle management is important, as is true of patients with diabetes mellitus.

The clinical guidelines for the treatment and management of diabetes are well established. Prescriptions, and lifestyle-related health management (diet and/or exercise) can be entrusted to nurses without compromising the quality of care. Patient compliance with chronic disease management is essential [24]; customized treatment plans focusing on prevention and management rather than treatment are required. Frequent contact with a readily available management team, which may include physicians, nurses, dietitians, exercise specialists, and professionals in related fields, enhances psychological stability; this is the rationale behind “humanistic” or “whole-person” treatment. A team effort improves education and monitoring. Again, frequent communication is important, as is access to information from both the hospital and the patient’s home. The patient can report frequently on his/her condition.

### CLINICAL APPLICATIONS OF U-HEALTHCARE

Medical care needs to change from uni- to bi-directional. Developments in information technology (IT) and the development of many new medical devices have encouraged recent research projects on healthcare communication [25-30]. U-healthcare combines IT and medicine, allows contact anytime with health management and medical services, and is being introduced both domestically and internationally (primarily targeting diabetics) [31-37]. Patients with chronic diseases, such as diabetes or hypertension, are still required to visit medical professionals every 3 to 4 months, but U-healthcare aids in management between hospital visits. Via a mobile phone or the Internet, patient places personal information (blood sugar level, drug use, and hypoglycemic status) onto a server, and the data are then delivered to a U-healthcare center. A medical team next reads and analyzes the information, and a medical team member responds if a problem is apparent (Fig. 1) [35-38]. Many patients have already expressed the desire to participate in U-healthcare [35], and an Internet-based glucose monitoring (IBGM) system has been developed. In one study, a significant decrease in the level of HbA1c was evident in diabetic patients who used the system for 3 months; indeed,



**Fig. 1.** Scheme of the ubiquitous healthcare system.

those with higher baseline HbA1c levels benefitted particularly [39]. Furthermore, a 3-month trial yielded benefits that lasted for up to 30 months [40]. Thus, IBGM not only reduced HbA1c levels but caused such levels to become stabilized. It appears that the program motivated patients to manage blood sugar levels continuously. Thus, U-healthcare was successful. Similar results have been obtained in other studies [25-40].

To participate in IBGM, a patient must have access to a computer with an Internet connection. Thus, patients in rural areas where the Internet is not accessible, or elderly patients unfamiliar with computers or the Internet, are unable to access U-healthcare. IBGM can be performed only in urban areas with readily available Internet connections. In addition, this U-healthcare is accompanied by continual direct, personal treatment, including visits to medical professionals. Therefore, patients with poor accessibility to specialized medical institutions cannot use U-healthcare. Flexibility and accessibility must be improved to support systematic diabetes management more effectively. A new system featuring personal data assistants with inbuilt blood sugar-monitoring capacities was trialled at a public health center in a farming community with limited access to medical professionals and treatment. HbA1c

levels improved significantly [41], confirming that IBGM was indeed effective at managing diabetes in a rural area with only a public health clinic. This illustrates the benefits of linking medical care to a mobile device.

### HEALTH ECONOMICS: HOW CAN WE REDUCE THE COST OF MEDICAL CARE?

The economic benefit of a U-healthcare system must become clear if the system is to be widely accepted. In other words, it must be shown that the medical and social cost reductions achieved are greater than the expenses associated with establishment, application, and maintenance of the system. Such costs include commercialization, provision of new devices, the labor of medical teams, systems maintenance, and server management. Any measure enhancing patient care and satisfaction, while minimizing personal expense, must be cost-effective [42]. Artificial intelligence systems minimizing the medical manpower necessary for effective patient management are required. Such software would maximally reduce social and medical expenses. In fact, such a program (System for Automatic Verification, or SAVE) was recently applied in

clinical research, and reduced physician labor by 50%, thus affording efficiency, stability, and economic benefit. SAVE will contribute to commercialization of U-healthcare systems by reducing labor costs [43].

## WHAT ARE THE LIMITATIONS OF U-HEALTHCARE?

### Provision of medical services

#### *Low compliance by medical institutions and physicians*

Many medical institutions and their affiliated physicians lack an awareness of U-healthcare, and distrust it. Many will view a new technology such as U-healthcare negatively, particularly when this is not profitable. Incentives are required. Also, currently, a physician would be absolutely liable for any medical accident associated with U-healthcare.

#### *Lack of clinical trust, experience, and knowledge*

Physicians are accustomed to treating patients in their offices or hospitals. Currently, most doctors lack the experience and knowledge necessary for management of patients outside a hospital. This is particularly so when medical services are expanded to include lifestyle management (e.g., diet and exercise) and encouragement of patient compliance (e.g., with administrative requests and disease management). Doctors lacking the necessary experience will require expert medical and systems support.

### Medical service customers

A patient may be reluctant to entrust private health-related information and health status reports to a U-healthcare system in the absence of legal standards and/or institutional support. U-healthcare credibility must be established by providing empirical evidence that engenders trust, defines any personal costs, and establishes a financial system both allowing and compelling a patient to pay reasonable costs. Investment by leading companies, and governmental promotion, are necessary.

## THE ROLE OF POLICYMAKERS

Policymakers create legal and institutional acceptance, provide essential support, and make the changes necessary for establishment of U-healthcare. The current boundaries of telemedicine must be broadened. Today, U-healthcare focuses principally on lifestyle management. The training of, and the roles played by, healthcare workers who are not physicians

but, rather, nutritionists and exercise specialists, must be regulated. In addition, new specialists, such as U-healthcare nurses, must be trained, and the rules of in-house treatment, including that performed by visiting nurses, must be relaxed, particularly on military bases and in remote or medically underdeveloped areas.

### Who is liable?

Liability is ambiguous if a medical accident not associated with diagnosis or treatment (e.g., equipment failure or a communication problem) occurs during U-healthcare. Medical professionals will refuse to engage in such care unless the law clearly places any liability elsewhere.

### Acceptance of U-healthcare by health insurance providers

Currently, U-healthcare is not covered by many medical insurers, including the Korean national health indemnity provider. Therefore, costs fall on consumers and (some) local governments. Telemedicine will not become readily available or accepted if the care remains unrecognized by medical insurers.

### Incentives for healthcare institutions are low

Although prevention of complications greatly aids in chronic disease management, the incentives for hospitals to prioritize such practices are low. Any emphasis on prevention and management of complications is often insignificant, except in public health programs. In some developed countries, including the United States, the United Kingdom, and Germany, the newer approach is becoming a focus of standard medical services, driven by incentives offered to medical institutions and physicians who reduce medical expenses by practicing preventative methods [44-47].

### Protection of personal health information

U-healthcare is possible only if health information is secure but also available outside of medical institutions. The collection, handling, distribution, and use of personal health information gathered via the Internet must be safeguarded; urgent research is needed.

## HOW DO WE START?

The amount of time a patient spends with medical professional(s) is currently extremely limited. Can both lifestyle and medical needs be managed via one consultation every 3 months with a medical professional? A diabetic patient has a primary need to be

healthy, and a secondary desire to make lifestyle changes after diagnosis. Demands form when financial conditions allow and the will to take action develops. As disease management changes focus from treatment of acute disease to a management-based treatment plan [1,2], the demand for health management may exponentially increase, but the systems in place to support the demands are inadequate. If a “low-cost” lifestyle management system were available, this would afford the opportunity to maintain and improve life, and would reduce the enormous social and economic costs of healthcare.

How can U-healthcare be developed and implemented? This form of care, the new paradigm of chronic disease management, will require extensive innovations in medical equipment, wireless communications, computer databases, and software processing large amounts of data. The U-healthcare system has three particular requirements (Fig. 1): monitoring devices and sensors that measure biometric data; networks that transmit data; and medical analyses of, and responses to, the data. U-healthcare will be in increasing demand when all three requirements are met. Mobile devices like Smartphones and tablets are becoming ubiquitous and increasingly powerful. Sensing devices and networks will become more sophisticated, enhancing medical applications in chronic disease management. Currently, both the necessary sensing devices and networking facilities are inadequate. Evidence-based improvements and proof of successful clinical application are essential. Governments should financially support commercial concerns and hospitals that combine to empirically demonstrate the effectiveness of U-healthcare. Simultaneously, a large clinical research team should be formed. The team should include representatives of government; corporations producing and developing the necessary equipment, services, and systems; and hospitals and clinics supporting U-healthcare. Committed long-term governmental support is essential to ensure the immediate application of programs that are demonstrably effective and stable.

Since we are bringing in a new system, we shouldn't expect that everything will go well. The process should start small and then grow rapidly. There must be more clinical trials to have definite clinical evidence. Medical staffs in hospitals have to be in charge of the clinical research and provide technical supports and patents. The government and Insurance companies should build a guideline and reward of the new system and apply them to local clinics.

## CONCLUSIONS

Although non-trivial problems remain, it is clear that U-healthcare is very attractive when diabetes is to be treated. Although not all required changes can be simultaneously introduced, it appears that some such changes will undergo clinical testing and implementation in the near future. After U-healthcare treating diabetes has pioneered, other various conditions or diseases such as hypertension [48,49], obesity [50-52], cardiac patients [53-56], and cancer [57-59] can be similarly managed. Such initiatives will be rapidly introduced when the benefits of U-healthcare in diabetes treatment become evident.

New forms of management of chronic disease are under development. These exploit cellular and social networks, analyze large amounts of data, and feature genomic sequencing. The entry of IT into medical treatment is inevitable; many countries are already competing to be the leader.

Excellence and innovation are required to become globally competitive. South Korea, which has excellent IT infrastructure, can become a world leader in the field, adding to the nation's international reputation. Also, the technology may allow early diagnosis of chronic diseases, which can then be treated promptly, reducing the risk of later complications. U-healthcare and the associated technology will be commercially very valuable, and innovations in equipment, sensors, and communications infrastructure may be expected.

## CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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