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**Telehealth management program for patient care in NTUH**

— A 10-year experience

The Telehealth Center of National Taiwan University Hospital was established in 2009 (Figure 1). Our center provides the fourth generation of a synchronized, integrated, remote management program for patients with multiple chronic diseases. The goal of our telehealth management program is to reduce the number of unplanned hospitalizations and improve overall health outcomes with the assistance of advanced monitoring and communication technologies. This telehealth management program provides the following services: (1) Remote monitoring of biological data, including single-lead electrocardiography, blood pressure, heart rate, and pulse oximetry, which are transferred from the patients' homes to our center on a daily basis and on-demand; (2) comprehensive case management, for which purpose nurse case managers communicate with patients daily and on-demand by telephone to improve patient adherence to medication regimens and to provide personalized medical instruction; (3) continuous support from the medical team, which includes full-time nurse case managers and cardiologists who are in charge of the telehealth management program 24 hours a day; and (4) integrated long-term care, with discussions conducted regarding long-term medications and management with the patients' primary-care physicians if acute conditions occur. Our telehealth program emphasizes the prevention and early detection of clinical deterioration as well as continuous, evidence-based medical care.
Our center is dedicated to the study of the application of telehealth care to the management of patients with chronic illness. In our earlier studies, we found that patients in our telehealth care program had better blood pressure levels and blood sugar control after joining the program. These effects can be observed as early as one month after joining our program. We have also shown that our telehealth program reduces the burden and emotional stress on caregivers one month after the patients join our program. In subsequent studies, we have shown that our telehealth program is associated with fewer hospitalizations and lower total medical costs, both in a before-after study and in comparison to a matched control group [1,2]. Finally, we linked our patient-level data to the mortality database in the Ministry of Health and Welfare. The all-cause mortality rate of the patients who joined our telehealth program was significantly lower than that of the matched control group [3].

Our center has also explored novel applications of telecommunicating technologies to disease diagnosis and monitoring [4]. Using the more than 100 thousand electrocardiography datapoints acquired during the 10 years the program has been in operation, our IT team developed an automatic ECG diagnostic algorithm. We then used this algorithm to conduct a screening program in a nonmetropolitan area in Jinshan Dist., New Taipei City. Our results showed that this algorithm can identify patients with atrial fibrillation, with an accuracy greater than 95%. Moreover, using the photographs of pacemaker wounds uploaded by our patients, our IT team developed an algorithm to automatically process the photo and identify infected wounds. With the help of this automatic wound infection detection algorithm, our nurse managers can identify patients with wound infections more confidently and earlier, enabling them to refer patients for appropriate care in a timely manner.

Recently, our center has explored the effect of urban-rural differences on the application of and the business model for telehealth services. Our study, which was conducted in both urban and rural areas, revealed differences in service users’ attitudes towards and expectations of telehealth care between these two areas. Urban users have a better understanding of ECGs and blood oxygen levels; these users indicate that both vital signs should be measured and monitored in telehealth services. There are also differences in the problems facing the service providers between these two areas. Urban providers are more concerned about frontline implementation issues such as system integration and human resource support, while rural providers are more concerned about policy-related insufficiencies such as long-term care, research and development, and the National Health Insurance subsidy.

These results provide evidence that telehealth providers can use to tailor their business models in different areas. The value propositions of telehealth services for urban and rural regions are clearly different, as their customer needs are entirely different. The telehealth service providers must embrace a patient-centered mindset to empathize with and pinpoint the needs of their customers, and they must design and develop their service models accordingly. As technology advances, system platform integration for both service providers and receivers must align with the value proposition mentioned above. It is important to consider not only the user experience from the patient side but also the experience and perception of the physicians and nurses. The typically intangible and ignored value of prevention and early detection in medical and healthcare services must be explicitly recognized and appropriately rewarded. It has been proven and appreciated that telehealth is capable of delivering preventive and early warning services to those in need. This contribution will be further magnified with the increasing prevalence of telehealth.
Telehealth management program for patients with chronic renal disease and for AF screening

The Telehealth Center of National Taiwan University Hospital, established in 2009, provides a synchronized and integrated remote management program for patients with multiple chronic diseases. We have shown in our prior studies that this synchronous telehealth management program improves blood pressure and sugar control, reduces the burden of caregivers and is associated with decreased rehospitalization and all-cause mortality compared with usual care. Our center is dedicated to exploring new applications of advanced technology in the remote care of patients.

We evaluated the effect of renal function status on hospitalization among patients participating in our telehealth management program in a recent paper [1]. Among the 715 patients enrolled in this study, chronic kidney disease was a risk factor for hospitalization. Moreover, we found for the first time that the contract compliance rate (to a telehealth management program) in these patients had a triphasic relationship with cardiovascular and all-cause hospitalization. Patients with low or very high contract

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