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Artificial Intelligence (AI) Policy Recommendation on Digital Transformation for Healthcare Ecosystem - Case Study Report

APEC Policy Partnership on Science, Technology and Innovation

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CASE STUDY REPORT

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Executive Summary

The rapid progression and breakthroughs in computation science have led to the emergence of innovative devices by using algorithms of artificial intelligence (AI) and machine learning (ML) in recent years. Together with the big data analytics facilitated by digital health platforms, these novel AI/ML devices are reshaping the landscape of healthcare at an accelerated pace. Facing the revolution in healthcare rooted in AI/ML, the incorporation of these novel devices into the workflow for the provision of healthcare can be a challenging task as a result of professional autonomy, interpretability, technical issues associated with the internet, data format, digital platforms, and hardware, economic considerations, and cultural context. As an illustration, Chinese Taipei demonstrated the implementation of AI Box, an AI/ML-based device for the detection of diabetic retinopathy in the primary care unit of Dr. Kao's Clinic in a resource limited community, Fuxing district, Taoyuan city in this project. Through this case study, the framework of using AI/ML devices to assist the screening process of diabetic retinopathy among residents in a rural area without ophthalmologists was demonstrated. Through the collaboration between public and private sectors, the implementation of AI/ML technology in healthcare services to benefit the population, providers, and the society can be realized.

1. Introduction

The breakthrough in computation science and innovations in the algorithms of artificial intelligence and machine learning (AI/ML) have greatly reshaped the landscape of health service toward precision and digital health in recent years. In spite of a series of novel AI/ML technologies that have been developed with the empirical evidence strengthen the application of these new modalities into daily clinical practice [1], the realization of incorporating AI/ML technologies into the workflow of clinical practice is still a challenging task for most of APEC economies [2-5].

The theme of "**Best Practice Sharing on How to Provide High Quality of Healthcare by the Use of AI Technologies**" was thus incorporated in the project of Artificial Intelligence Policy Recommendation on Digital Transformation for Healthcare Ecosystem held by Chinese Taipei on August 12, 2021 [6]. In this theme, the incorporation of AI/ML technologies of a variety of fields into health enterprise and clinical practice was the main focus. Experts from the APEC economies were invited to share their experience on the implementation and realization of AI/ML technologies in pharmaceutical development, precision oncology, AI in ophthalmology including glaucoma and diabetic retinopathy, and the filed application of such a novel module to benefit clients, patients, healthcare provider, and the society as a whole.

In this report, a case study on incorporating AI/ML technology for detecting diabetic retinopathy as part of the workflow in a primary care setting with limited resources were illustrated by Chinese Taipei. On the basis of this illustration, we not only attempt to demonstrate a model for using current AI/ML technology to facilitate the provision of healthcare service but also to address the obstacle that may be encountered in the implementation.

2. Background

The population of Chinese Taipei is aging rapidly. In 2018, the APEC economy of Chinese Taipei became an aging society, with the senior population aged 65 years and older accounting for 16% of the total population. The medical needs including the chronic diseases of cardiovascular disease, diabetes mellitus (DM), metabolic disorders, and associated degenerative disorders are expected to increase as a result of the aging population. To address these health issues, we thus attempt to apply the technologies of AI/ML together with the digital health platforms established for disease prevention from the Health Promotion Administration (HPA), Ministry of Health and Welfare and healthcare service from the NHI Administration, Ministry of Health and Welfare, Chinese Taipei to facilitate the provision of digital health services.

Among the chronic diseases highly associate with an aging population, diabetes mellitus and one of the main complications, diabetic retinopathy, accounts for the main cause of disability. The complexity for the identification of diabetic retinopathy makes it difficult to detect such a severe complication at an early stage by when effective intervention can be initiated to prevent its progression. These characteristics also render the detection of diabetic retinopathy a resource-demanding process.

In the face of these obstacles, the collaboration between the public sector of HPA and Industrial Technology Research Institute (ITRI) and the private sectors of healthcare providers including the hospital at different levels were initiated by Chinese Taipei to create a regional diabetes fundus examination service network to increase the participation rate of fundus examination among patients with diabetes mellitus.

3. Case Study Report

The fundal examination is one of the evaluations that should be performed routinely on a regular basis for all patients with diabetes mellitus to detect microvasculopathy at the earliest. Guided by the result of this examination, interventions such as phototherapy can be administered to patients with diabetic retinopathy to prevent its progression and further to the disabled status among the population of diabetes mellitus.

As of 2016, there were around 2.55 million people (10% of the population) were diagnosed with DM in Chinese Taipei. For the entire diabetic population, 75-80% of the patients seek medical visits (1.96 million). Among the DM patients receiving healthcare services, 63% (1.24 million) were cared for by local clinics, and only half of these patients received fundoscopic examinations biennially. Regarding the follow-up care for diabetic retinopathy, 35% of these patients (218000) were referred to ophthalmologic departments (**Figure 1**).
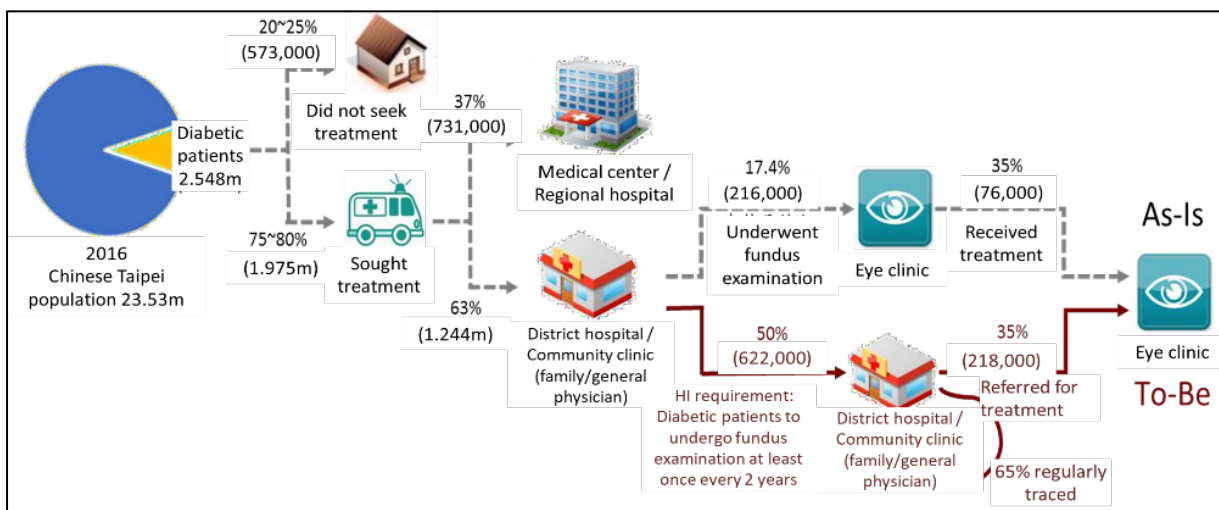

Figure 1. Patient flow of DM and diabetes retinopathy for Chinese Taipei.

The provision of fundal examination across the levels of healthcare services is crucial and should be deemed as a basic requirement of quality assurance for caring for diabetes mellitus patients. However, such a routine examination is conventionally provided by ophthalmologists involved with an inconvenient and time-consuming process such as mydriasis before the examination. With the soaring number of diabetes mellitus patients resulting from an aging population, the capacity in the provision of this healthcare service to the expanding patient cohort can be insufficient. Furthermore, the treatment for patients with the abnormal result of fundal examination involved a bidirectional referral between the primary care unit which is responsible for long-term care of the patients and the regional hospital or medical center which is responsible for the treatment of diabetic retinopathy, which can further decrease the effectiveness of the intervention.

These issues including the complexity in the provision of fundus examination at a regular basis to a population of diabetes mellitus, the requirement for data exchange between the primary care provider and regional hospital/medical center, and a referral system for the continuum of patient care motivate the development and implementation of AI/ML. The application of AI/ML devices in a primary care setting can be further hampered by issues such as the referral system connecting primary care units with the hospital, data sharing platform, and internet connections, which can be a barrier for a sustainable implementation especially for a resource limited area. The difference in the workflow between primary care units and the hospital may further perplex the implementation.

3.1 The implementation and validation of the AI/ML technology into the workflow in hospital setting

For assessing the feasibility of integrating the innovative AI Box using deep learning systems as a screening tool for the detection of diabetic retinopathy in a hospital setting, the device was introduced into Taipei City Hospital. DM patients were first screened for diabetic retinopathy by using the AI Box. Following the risk level of diabetic retinopathy identified by using the AI Box, the patients were referred to ophthalmologic department for confirmatory diagnosis.

Among the 459 patients enrolled for using AI Box in the hospital setting, 56 subjects with abnormal results were identified. All of these subjects with positive result complied with referral to ophthalmologic department for confirmatory examination, which revealed a 96% accuracy in detecting diabetic retinopathy of all types. In this filed implementation of the AI/ML device of AI Box, the feasibility in incorporating into the workflow of medical service in a hospital setting was demonstrated. The validity in using AI Box as the screening tool for detecting diabetes retinopathy was verified, which strengthen the evidence for the clinical use of the AL/ML device toward digital health and precision healthcare.

3.2 The implementation of the AI/ML techonology into the workflow in the setting of primary care service

Following the implementation of AI Box in a hospital setting, we further deploied this AL/ML device in a primary care setting through a community medical network to realize digital transformation for smart healthcare. Although the use of AI Box in a hospital setting demonstrated the feasibility in incorporating the AL/ML based device into the workflow of health care, its application in primary care setting can be hampered by issues such as the referral system connecting primary care units with hospital, data sharing platform, and

internet connections, which can be a barrier for a sustainable implementation especially for a resource limited area. The difference in the workflow between primary care units and hospital may further perplex the implementation. We thus extend the use of AI Box in a primary care setting.

To evaluate the feasibility of the implementation of AI Box in a primary care setting after prior experience in the Taipei City Hospital, Dr. Kao's Clinic in Fuxing District, Taoyuan City, Chinese Taipei has collaborated as the site for implementation. Although the healthcare services in Chinese Taipei are highly accessible, there is a remarkable disparity in terms of the number of medical practitioners and healthcare facilities between the urban and rural areas. Taking Fuxing District in Taoyuan, a resource limited mountain area in Chinese Taipei, as an example, the district is sparsely populated with inconvenient public transportations between the communities of this area. Regarding the geographic characteristics, the Fuxing district comprises one third of the entire Taoyuan City, which is populated with 12000 residents (0.54% of entire Taoyuan City) that are distributed in thirteen mountain communities. Two major routes of transportation, the seventh provincial highway and the Luoma road are the only roads running through the district. There are a few public transportations available in this mountain area. In contrast to a total of 825 clinics around Taoyuan City, there are only seven licensed doctors (four family medicines, one neurologist, one chest medicine specialty, and one dentist) available in this area. The ophthalmologic service in this area can barely be accessed. As a result, it is difficult for DM patients in the Fuxing District to receive fundoscopic examinations as routine care even with the recent establishment of local institutions, home-based health services, and transportation services in this area.

As a primary care unit, the Dr. Kao's Clinic funded in 1990s by Young-Wei Kao, an indigenous Atayal physician, has provided medical services to the residences including the aboriginal people of the Fuxing district. During the medical services provided by Dr. Kao for three-decade long, the continuum of healthcare is often hampered by the resource limited situation mentioned above. This is especially true for detecting diabetes retinopathy among DM patients.

The AI Box developed by ITRI provides a good chance to overcome this difficulty. With a valid result demonstrated in the hospital setting, Dr. Kao's Clinic incorporated this AI/ML device in the workflow for caring DM patients as depicted in Figure 2. As a portable device, AI Box can be used in the settings of the clinic, home-based medical care, and mobile medical services. The results of fundus examination derived from AI Box for DM patients in the Fuxing district were first evaluated by an ophthalmologist by using a telemedicine approach with the image and reports transported digitally (Figure 3). The confirmed results were then transferred to Dr.

Kao's Clinic with the suggestions from the ophthalmologist. Subjects with abnormal results were then be referred to the eye clinic for further evaluation and treatment ("Immediate referral" or "Referral in three months", depending on the risk level of diabetic retinopathy evaluated by AI Box). Attendees with normal results were provided with the suggestion of follow-up on an annual basis.
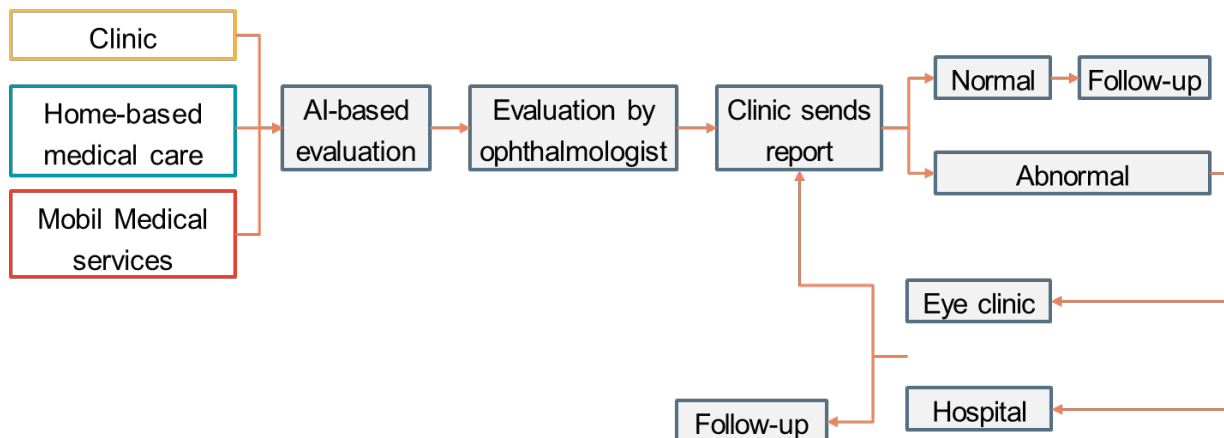

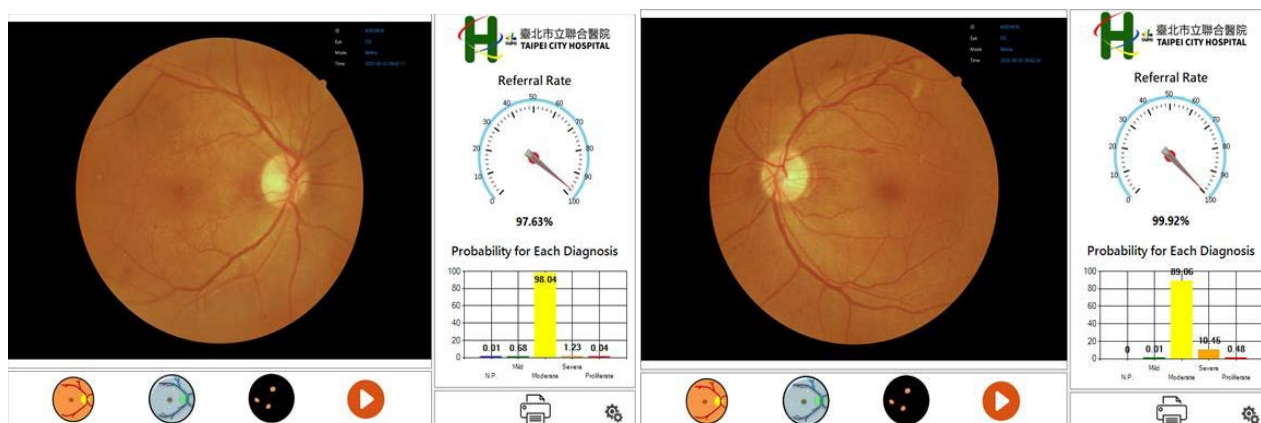**Figure 2. The workflow incorporating AI Box for detecting diabetic retinopathy in Dr. Kao's Clinic.**

Figure 3. The result of AI Box screening for diabetic retinopathy.

Figure 4 shows the results of suggestions on the basis of the diabetes retinopathy risk levels evaluated by using AI Box. Among the attendees, 79% with the normal result and annual follow-up were suggested. A total with the risk of diabetes retinopathy were identified, of whom 7% and 14% were provided with the suggestion of "Immediate referral" and "Referral in three months", respectively. For the attendees requiring referral, 29.3% complied with the suggestion.
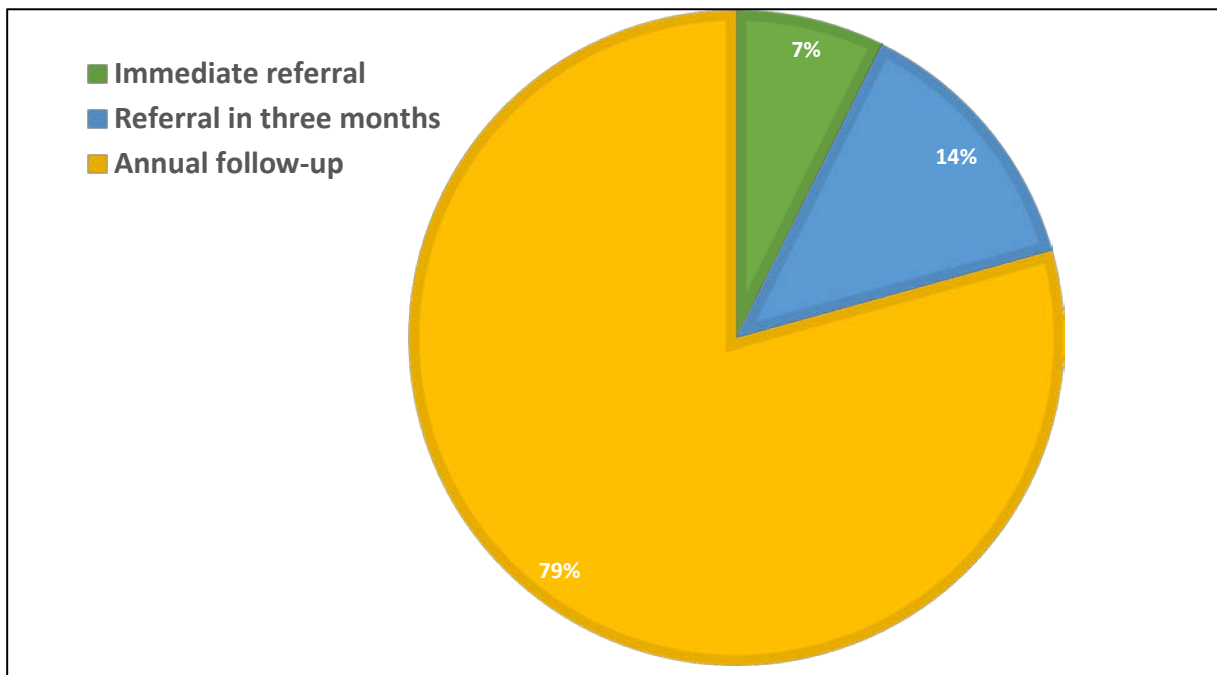
Figure 4. Results on the suggestions on the basis of risk levels evaluated by AI Box.

Figure 5 shows the impact of the introduction of AI Box as a routine service incorporated in the primary care setting in Dr. Kao's Clinic in 2018. For the entire Fuxing district, the rates of fundoscopic examination and color fundus photography increased steadily from year 2011 to 2020, approaching the overall regional average of 50%. Regarding the rate for Dr. Kao's Clinic with the implementation of AI Box, the rate increased significantly since year 2015 and peaked in 2018, exceeding the overall regional average of 50% in year 2018.
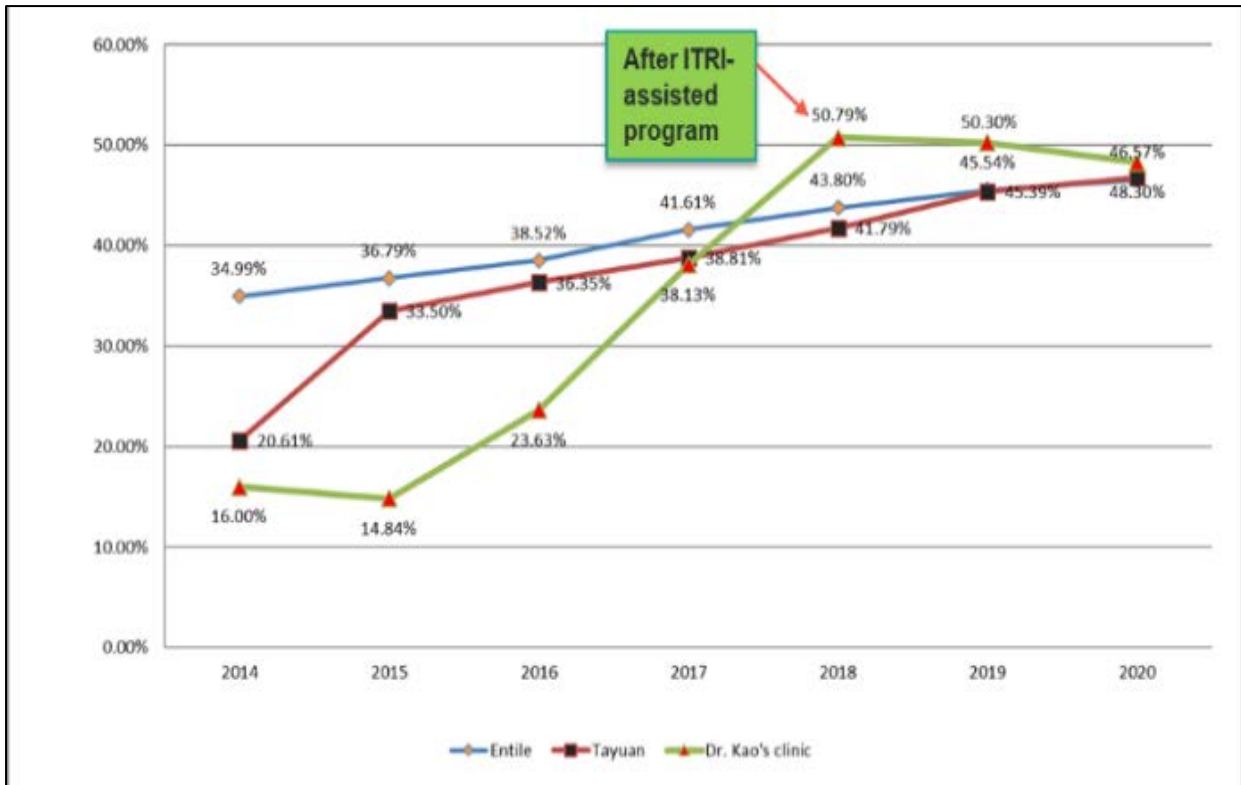
Figure 5. Rates of fundus examination for DM patients before and after the introduction of AI Box in Dr. Kao's Clinic.

4. Conclusion

Illustrated by the case study of using AI Box as a screening tool for the early detection of diabetic retinopathy for DM patients, we aim to provide a feasible service model incorporating AI/ML device into the provision of healthcare in both hospital setting and the primary care in the community to those APEC members to reach the goal of digital healthcare with precision medicine. The proposed AI/ML device of AI Box targeting the unmet need of fundoscopic examination for DM patients in the primary care setting vividly demonstrates the usefulness of AI technologies in improving the accountability of healthcare providers and the accessibility of patients and clients.   More importantly, through such a demonstration, the usefulness and the perspective of AI technologies in digital transformation for healthcare in the context of each economy of APEC can be inspired.

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