

Telemedicine System Based on Medical Consultation Assistance Integration

Jhe-Wei Lin¹, Cheng-Yan Siao¹, Rong-Guey Chang¹, Mei-Ling Hsu²

¹Department of Computer Science and Information Engineering, Advanced Institute of Manufacturing with High-Tech Innovations, National Chung Cheng University, Chiayi

²Department of Information Technology, Ditmanson Medical Foundation Chia-Yi Christian Hospital, Chiayi
Email: hcyen103m@cs.ccu.edu.tw

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Abstract

With the aging of the global population, how to provide effective telemedicine for the aging population has become a very important issue, especially for the elderly with limited mobility. If there is a complete telemedicine system, it will not only greatly improve medical efficiency. It can reduce the chance of contact between people and avoid the medical risks caused by severe special infectious pneumonia. This paper focuses on the development of a high-efficiency telemedicine system platform that conforms to international standard data exchange formats. This system platform can not only solve the problem of shortage of medical staff but also allow patients to be free from medical outpatient time constraints. Achieve the effect of telemedicine at any time, and digitize the medical process rules to establish a complete online telemedicine system platform.

Keywords

Telemedicine, Medical Care System, Fast Healthcare Interoperability Resources

1. Introduction

With the development of medical technology, the average life expectancy of the global population continues to increase [1]. How to improve the efficiency of social medical treatment has become a topic that cannot be ignored. According to research by the United Nations Department of Economic and Social Affairs Office [2], the global support ratio of the elderly population by 2050, the number will be reduced to 4, indicating that the country's burden of supporting the elderly population is increasing. If there is no comprehensive medical system, when

an unexpected outbreak occurs, the national medical system will break.

With the continuous development of current technology, new types of viruses have gradually affected the world. Particularly serious in recent years, COVID-19 is very heavy impact. [3] It not only affects global economic development but also affects the human lifestyle. The current medical system can no longer cope with the medical capacity of countries around the world, if there is a set of instant telemedicine systems that can quickly transmit medical information without delay when patients are consulting, it not only can reduce the amount of medical treatment, but also make it more convenient for the elderly with mobility impairments, and for hospitals, it can reduce the chance of infection caused by crowd gathering.

Before the emergence of COVID-19, many countries have actively promoted telemedicine systems. Portugal proposed the National Strategic Telehealth Plan [4] for medical infrastructure, collaboration systems, and services to improve the regulatory framework. In addition, Germany proposed the Telemedical Maritime Assistance Service [5] to ensure that when a global emergency medical situation occurs, the medical hotline immediately operates radio medical treatment. After the outbreak of COVID-19 in 2019, the development of telemedicine systems has been accelerated, and telemedicine systems are gradually moving towards precision, immediacy, and complete research and development. According to the definition of the World Health Organization [6], telemedicine refers to medical behaviors and health information transmission using real-time video and data communication technology for diagnosis, consultation, and treatment. In addition, with the development of Industry 4.0, the new thinking of smart medical treatment is so derived [7], telemedicine is an important pioneer in the development of smart medical systems. It not only brings revolutionary changes to traditional medical services, but doctors can also assist medical decision-making, reduce errors, and avoid medical disputes from rapidly accumulating data. Create new opportunities for smart medical care.

We designed and implemented a web page telemedicine system that allows patients to conduct medical consultations in a remote manner through various information equipments. In addition to regularly feeding back the system platform with data for self-measurement of physiological conditions, it also provides long-term medical staff tracking the patient's physical condition to meet non-essential contact requirements, that is, the system platform exchanges opinions between the two parties. The biggest difference between our system and other systems is that we are designing for the real-time feedback system, which conforms to the international standard data exchange format. Under the premise, we analyze the format of the data. Even if the amount of data is huge, the system can still operate normally, without affecting the rights of patients and influencing doctors to treat patients.

In this paper, we introduce a high-efficiency and real-time telemedicine system platform. The other parts of the paper are described below. Section 2 is the

related work. Section 3 is the description of the platform operation process. Then we show the experimental results in Section 4. Finally, we conclude this paper in brief in Section 5.

2. Related Work

2.1. Telemedicine Communication Technology

With the rise of 5th generation mobile networks [8] and WIFI6 [9], the real-time transmission of data in telemedicine is accelerated, especially in areas with inconvenient transportation. Telemedicine can not only solve the medical inconvenience of people in space, but also shorten the time for people to seek medical treatment.

Telemedicine uses communication technology to lift the traditional medical care fixed area restrictions for patients, thereby improving medical quality and reducing medical costs. Therefore, communication technology is one of the core technologies for the development of traditional medical care into telemedicine. The increase in the penetration rate of wireless communication networks, the improvement of physiological measurement technology, and the rapid development of care medical equipment will drive the rapid growth of the telemedicine industry market.

2.2. Health Level Seven International

Health level seven international is an association defined in the telemedicine data exchange format [10]. By formulating a complete electronic health information framework and related standards, the 7 in the name corresponds to the seventh layer of the Open System Interconnection Model. It is expected that this framework, is conducive to the exchange, integration, and sharing of patients' medical information, and improves the privacy of patients and the quality of medical care [11].

2.3. Fast Healthcare Interoperability Resources

Fast Healthcare Interoperability Resources(FHIR) is an international medical data exchange standard format [12], which is mainly used to describe the data format and data elements of Electronic Health Records, and provide standard system information in the Application Programming Interface [13], and strengthened patient data exchange, covering not only medical institutions, medical records, hospital stay, and discharge and referral records, but also data exchange between insurance institutions and insurance institutions.

FHIR's biggest aim is to accelerate the effective communication of medical information among medical units and to use medical information widely on computers, tablets, and smartphones so that hospitals and patients can quickly and easily receive medical service information. FHIR is composed of a series of resource implementations. Medical staff use copying and fine-tuning resources to solve medical practice and management problems. The resource is a set of excel

worksheets that can be organized and used to record data. At present, in the FHIR R4 version of the standard [14], 145 types of resources are summarized. These resources can be divided into five categories, including foundation, base, clinical, financial, and specialized. The fields and fields contained in the resource are listed in a hierarchical directory. The affiliation, the data description of the field is attached next to the field.

In this way, each hospital can develop a customized FHIR extended data format definition, and publish the customized FHIR extended data format on the official website to provide everyone with a unified format standard reference source. Even after the patient is registered, the patient’s personal information can be included in the Implementation Guide, and the relevant patient code and files can be attached for other hospitals to download and apply.

3. The Proposed Approach

3.1. Patient Medical Form

We will refer to the FHIR standard specification to design the form design system, and then exchange information with other medical units and cross-system inter-connection functions. In our system, we will design for three FHIR resource types [15], which include Patient, Encounter, and CarePlan, as shown in Figure 1.

In addition, we use RESTful to obtain or access the JSON or XML format text files of the hospital’s internal medical record database. As shown in Table 1, various RESTful operation types are written in the form of Application Programming Interface, so that users can use them more efficiently.

3.2. System Interface

We use HTML, CSS, and Javascript programming languages to design a web

Base	<p>Individuals</p> <ul style="list-style-type: none"> • Patient 5 • Practitioner 3 • PractitionerRole 2 • RelatedPerson 2 • Person 2 • Group 1 	<p>Entities</p> <ul style="list-style-type: none"> • Organization 3 • HealthcareService 2 • Endpoint 2 • Location 3 • Substance 2 • Device 2 • DeviceComponent 1 • DeviceMetric 1 	<p>Workflow</p> <ul style="list-style-type: none"> • Task 2 • Appointment 3 • AppointmentResponse 3 • Schedule 3 • Slot 3 • ProcessRequest 2 • ProcessResponse 2 	<p>Management</p> <ul style="list-style-type: none"> • Encounter 2 • EpisodeOfCare 2 • Flag 1 • List 1 • Library 2
	Clinical	<p>Summary</p> <ul style="list-style-type: none"> • AllergyIntolerance 3 • AdverseEvent 0 • Condition (Problem) 3 • Procedure 3 • FamilyMemberHistory 2 • ClinicalImpression 0 • DetectedIssue 1 	<p>Diagnostics</p> <ul style="list-style-type: none"> • Observation 5 • DiagnosticReport 3 • Specimen 2 • BodySite 1 • ImagingStudy 3 • ImagingManifest 1 • QuestionnaireResponse 3 • Sequence 1 	<p>Medications</p> <ul style="list-style-type: none"> • MedicationAdministration 2 • MedicationDispense 2 • MedicationStatement 3 • Medication 3 • Immunization 3 • ImmunizationRecommendation 1

Figure 1. FHIR resource type.

interface for user login and functional requirements, as shown in **Figure 2**, and finally, a complete medical interface [16], as shown in **Figure 3**, so that medical staff can easily view patient’s material.

3.3. Medical Information Browsing Interface

At present, smartphones have become popular, and many hospitals have introduced

Table 1. RESTful operation instructions.

Operation	Method
Create	POST https://example.com/path/{resourceType}
Read	GET https://example.com/path/{resourceType}/{id}
Update	PUT https://example.com/path/{resourceType}/{id}
Delete	DELETE https://example.com/path/{resourceType}/{id}
Search	GET https://example.com/path/{resourceType}?search parameters...
History	GET https://example.com/path/{resourceType}/{id}_history
Transaction	POST https://example.com/path/(POST transaction bundle to the system)
Operation	GET https://example.com/path/{resourceType}/{id}/\${opname}

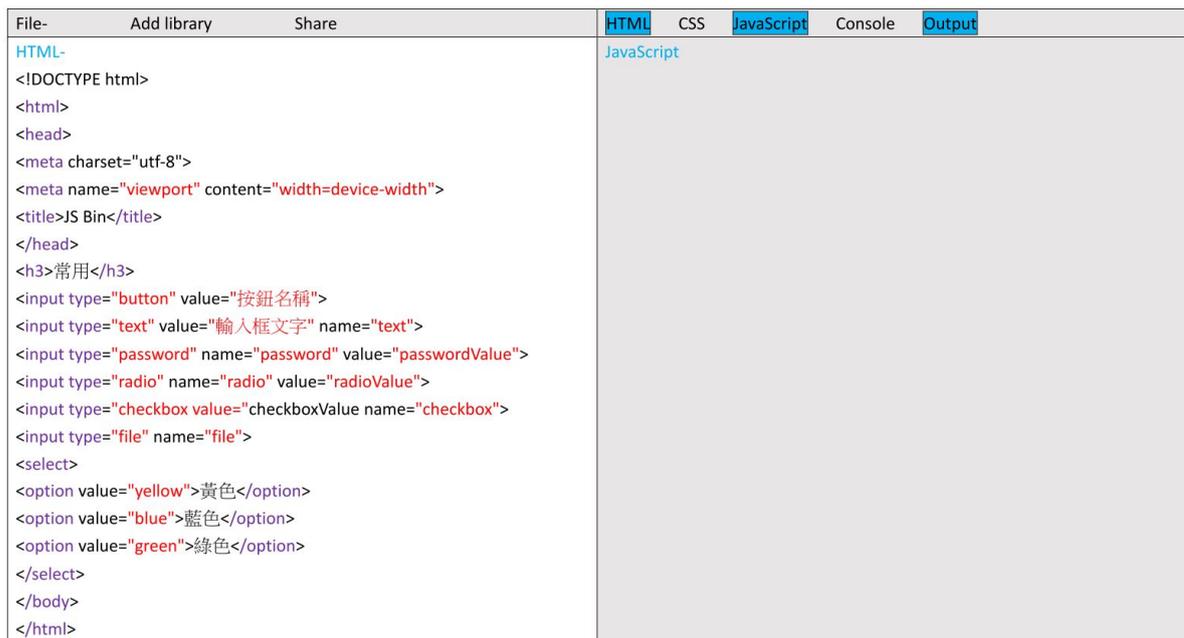


Figure 2. Front-end system design layout example.

Subject ID	Name Latest IMEI	Active Monitoring	Last Survey Score	Last Survey Time	Avg KCAL Last 24 hrs(AVG KCAL when mounted)	Current Battery Time Left Estimate	Data	Survey Answers	Survey Alarm	Message	Switch Active Flag
1014	END	YES	1	2014-06-23 21:26:02	1.325507(1.260188)	NA	view	view	set	edit	Deactivate
1001	END	NO	0	2013-12-02 10:07:56		NA	view	view	set	edit	Activate

Figure 3. Example of viewing user data on the medical side.

tablets to replace computers for medical care. In response to the above mobile communication devices, we will propose a mobile communication device system environment for telemedicine. Various mobile communication devices have different screen sizes. We use responsive web design technology to solve the problem of cross-platform use. As shown in **Figure 4**, the system can automatically detect the size of the user's Internet device and automatically adjust the graphic content of medical web pages for different screens to give users the best browse screen.

In addition, we integrate the Software Development Kit tools with the web system to build a rich application framework on the Android system and the iOS system. The application framework provided by the system can be adjusted according to the situation and can provide exclusive resources for different device settings. In turn, the efficiency of medical data transmission can be improved.

4. Experimental Result

4.1. Telemedicine System Implementation

We use Visual Studio as the development tool for the telemedicine system platform, which is mainly compatible with other telemedicine systems and has a complete set of relevant cross-platform device development tools.

4.2. Medical Records Conversion Electronic

The primary task of establishing a telemedicine system platform is to convert paper medical records into electronic storage. We use the medical records of Chiayi Christian Hospital as a reference, as shown in **Figure 5**, and use the database to design an electronic data table that matches it, as shown in **Figure 6**. When the patient creates the file for the first time, the corresponding data is stored in the FHIR database at the same time.

4.3. Patient Consultation Process

The proportion of the aging in the world is gradually increasing, and the proportion

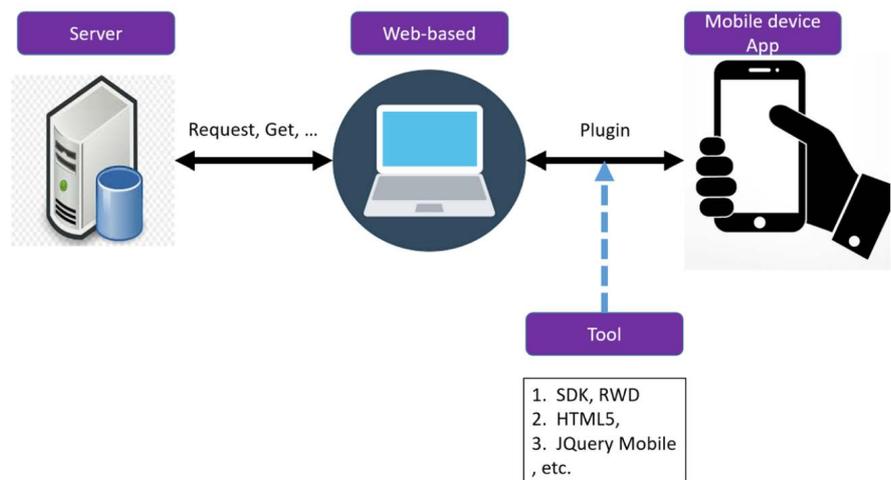


Figure 4. Mobile communication device integration webpage.

嘉義基督教醫院

初診病人基本資料卡

初診日期(First Visit Date):

First-visit patient personal information

年(Y) 月(M) 日(D)

姓名(Name):	身份證(ID No.):	電話(TEL)(H): _____ (O): _____ 行動電話(Mobile): _____
性別(Sex): <input type="checkbox"/> 男(Male) <input type="checkbox"/> 女(Female)	<input type="checkbox"/> 已婚(Married) <input type="checkbox"/> 未婚(Single)	身 高(Height): _____ 公分(cm) 體 重(Weight): _____ 公斤(kg)
出生日期(Birthday): 年(Y) 月(M) 日(D)	目前是否持有(Holding): <input type="checkbox"/> 身心障礙手冊(Disabilities) <input type="checkbox"/> 重大傷病卡(Catastrophic Illness Record)	
郵遞區號(Zip code) <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>		
地址(Address):		
電子信箱(E-mail):		
緊急聯絡人姓名: (Contact in emergency)	與病患關係: (Relationship with patient)	電話(TEL): _____ 行動電話(Mobile): _____

Figure 5. Example of a patient personal information.

病人背景資料

護字號: _____ 性別: 0 男 0 女 出生年月日: __年__月__日
 姓名: _____
 個案地址: _____ 電話: _____
 身高: _____ 公分; 體重: _____ 公斤; 血型: _____
 個案來源: _____



```

<Patient>
  <id value="" />
  <identifier>
    <value value="" />
  </identifier>
  <name>
    <text value="" />
  </name>
  <gender value="" />
  <birthDate value="" />
  <telecom value="" />
  <address value="" />
</Patient>
    
```

Figure 6. FHIR corresponding field.

of Chronic condition is also increasing year by year. Usually, the elderly with Chronic condition need to go back to the hospital for treatment, but for the elderly, it is a great physical burden. Therefore, through the telemedicine platform system we have developed, the patient and the medical end conduct medical consultation, as shown in Figure 7, and automatically store the medical data record, and use the collection of medical data as the data analysis data of the telemedicine system.

In this telemedicine system platform, the system will automatically collect various medical data of patients. Through the medical record data collected in the HL7 FHIR format, various patient physiological data, and medical history data are stored. The system can according to different data such as blood pressure, weight, a heartbeat before the physiological data has deteriorated, a reminder is issued in advance to alert patients to precautions and related measures. In addition, doctors use platform analysis to understand the user's use of the platform and the characteristics of the user population. Provide the improvement direction of this system and understand the user experience.

4.4. Telemedicine Login System Design

According to the user’s authority, we are divided into two identities: medical staff and patient. **Figure 8** shows that the user chooses the login identity according to his own authority when logging in to the system.

4.5. Medical Information Query

The user can select the medical data of the patient according to the name and time of the visit. It is worth noting that the user is not limited to the medical staff or the patient himself, but in the part of querying the medical data, we select according to the user’s login identity the difference is that if you are medical staff, you can query all patient data, but if you log in as a general user, you can only query your own medical information, as shown in **Figure 9**.

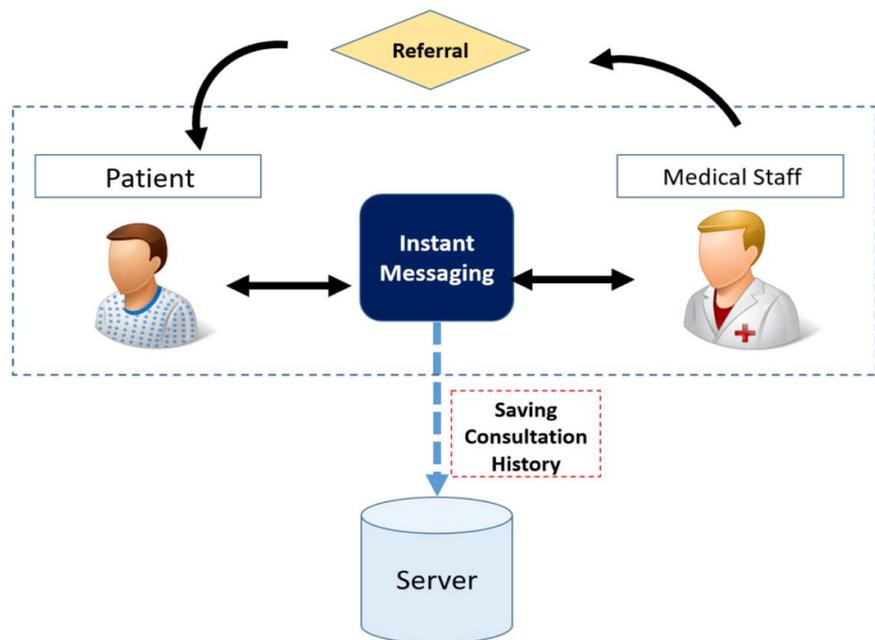


Figure 7. Telemedicine consultation process.

WebApp
Sign up
Sign in

Member Login

Login Name

Password

Login Identity General user
Medical staff

Figure 8. Telemedicine login system.

Danny Lin

Date Range ~

Medical Information

Figure 9. Patient information query.

5. Conclusion

We proposed a rapid and convenient telemedicine system and introduced the system to the Chiayi Christian Hospital. We received feedback from the hospital and found that most patients did not reject this system. Patients can use this system to avoid exhaustion when visiting a doctor, and our integration of the system into the mobile communication device, so that users can receive complete medical care without being restricted by equipment. The operation of this system meets the requirements of the medical consultation process. The reason is that the doctor analyzes the collected physiological data and medical record data. The medical staff can remind patients to pay attention to their physical conditions through the analysis results. However, a small number of patients feel that the system interface is not friendly enough. This is where we need to improve in the future.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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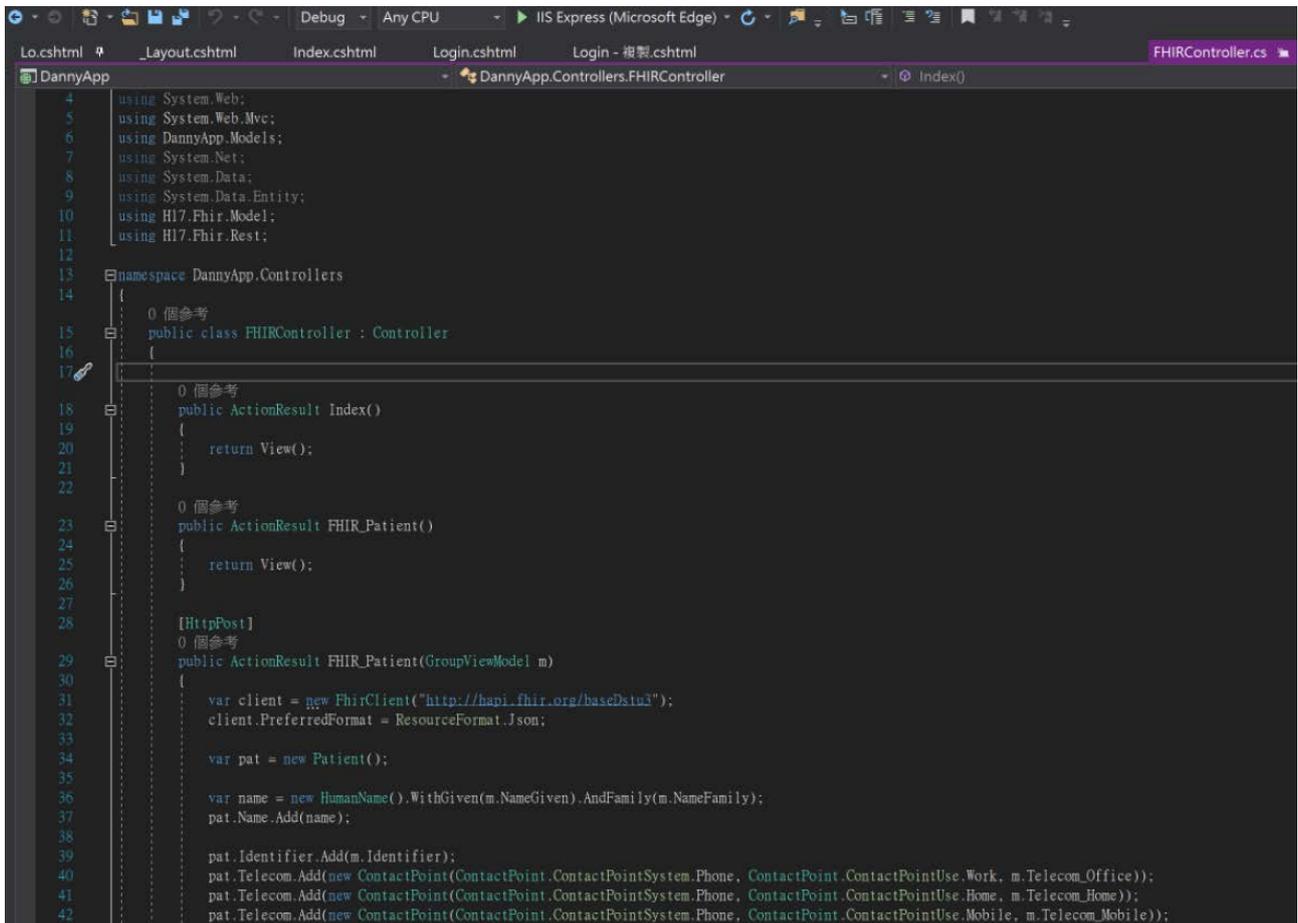
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Appendix A. Organization Structure of FHIR

```
<Patient xmlns="http://hl7.org/fhir">
  <id value="glossy"/>
  <meta>
    <lastUpdated value="2014-11-13T11:41:00+11:00"/>
    <meta>
      <text>
        <status value="generated"/>
        <div xmlns="http://www.w3.org/1999/xhtml">
          <p>Henry Levin the 7th</p>
          <p>MRN:123456. Male, 24-Sepc 1932</p>
        </div>
      </text>
      <extension url="http://example.org/StructureDefinition/trials">
        <valueCode value="renal"/>
      </extension>
    </meta>
  </id>
  <use value="usual"/>
  <type>
    <coding>
      <system value="http://hl7.org/fhir/v2/0203"/>
      <code value="MR"/>
    </coding>
  </type>
  <system value="http://www.goodhealth.org/identifiers/mrn"/>
  <value value="123456"/>
</id>
  <active value="true"/>
  <name>
    <family value="Levin"/>
    <given value="Henry"/>
    <suffix value="The 7th"/>
  </name>
  <gender value="male"/>
  <birthDate value="1932-09-24"/>
  <careProvider>
    <reference value="Organization/2"/>
    <display value="Good Health Clinic"/>
  </careProvider>
</Patient>
```

Appendix B. Telemedicine System Development Environment



```
4 using System.Web;
5 using System.Web.Mvc;
6 using DannyApp.Models;
7 using System.Net;
8 using System.Data;
9 using System.Data.Entity;
10 using H17.Fhir.Model;
11 using H17.Fhir.Rest;
12
13 namespace DannyApp.Controllers
14 {
15     0 個參考
16     public class FHIRController : Controller
17     {
18         0 個參考
19         public ActionResult Index()
20         {
21             return View();
22         }
23         0 個參考
24         public ActionResult FHIR_Patient()
25         {
26             return View();
27         }
28         [HttpPost]
29         0 個參考
30         public ActionResult FHIR_Patient(GroupViewModel m)
31         {
32             var client = new FhirClient("http://hapi.fhir.org/baseDstu3");
33             client.PreferredFormat = ResourceFormat.Json;
34             var pat = new Patient();
35             var name = new HumanName().WithGiven(m.NameGiven).AndFamily(m.NameFamily);
36             pat.Name.Add(name);
37             pat.Identifier.Add(m.Identifier);
38             pat.Telecom.Add(new ContactPoint(ContactPoint.ContactPointSystem.Phone, ContactPoint.ContactPointUse.Work, m.Telecom_Office));
39             pat.Telecom.Add(new ContactPoint(ContactPoint.ContactPointSystem.Phone, ContactPoint.ContactPointUse.Home, m.Telecom_Home));
40             pat.Telecom.Add(new ContactPoint(ContactPoint.ContactPointSystem.Phone, ContactPoint.ContactPointUse.Mobile, m.Telecom_Mobile));
41         }
42     }
43 }
```