Smart Hospital

By

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Abstract

Here write the abstract

Dedication and acknowledgements

Here goes the dedication.

Author's declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

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Chapter 1

Introduction

1.1 Motivation

The program will build a virtual hospital website called Smart Hospital, which aims to provide better access to medical care for residents in remote or medically underserved areas in Africa. Due to geographical limitations, transportation difficulties, and insufficient medical facilities, many residents often cannot receive good medical care. Through this virtual hospital website, residents in these areas will have the opportunity to consult with specialists remotely and receive more medical assistance and health support.
This project was initially part of a collaboration with the Africa Virtual Hospital initiative, which is dedicated to addressing healthcare disparities in remote and underserved communities across Africa. The initiative aims to connect these underserved regions with doctors and experts from around the world through its virtual hospital platform. However, despite the termination of the collaboration due to certain factors, our team chose to independently continue this project. In the context of rising global healthcare pressures, including an aging population, increasing rates of chronic diseases, and uneven distribution of medical resources, we recognize that establishing a digital healthcare website to provide telemedicine remains highly meaningful, particularly for regions with insufficient medical resources or limited access to healthcare.

1.2 Client Brief

This project was initially undertaken in collaboration with Africa Virtual Hospital. As the client, Africa Virtual Hospital proposed the development of a virtual healthcare software platform comprising the following five main components: Doctor Application, WhatsApp Chatbots for Patients and Service Providers, Caregiver Application, Nurse Application, and Electronic Health Record. Within this framework, our team's primary focus was on the doctor application, which was expected to run on multiple devices, including smartphones, tablets, and laptops.
The Doctor Application component was expected to include the following elements:

- Registration
- SSO/Welcome
- Home page (Appointments and Reviews)
- Calendar (Availability)
- Notifications
- Patient Profile
- Connect (Video and Voice to Patient WhatsApp)
- Treatment Plan and Orders
- Patient Information Feed
- My Supporting Staff
- My Profile

During the collaboration period, we developed the various webpages and features of the doctor application based on the design and technical resources provided by the client. However, with the termination of the collaboration, our team also lost the original technical support. And then our new client is our University, but given the constraints on development time and resources, our team adjusted the scope based on existing resources and the original proposal, re-planned the website architecture and front-end design, and prioritized retaining core functional modules such as the doctor-patient interaction interface and basic medical information viewing, to ensure the project's feasibility under current conditions.

1.3 Aims and Objectives

The aim of this project is to design and develop an easy-to-use, cross-device virtual hospital platform to promote telemedicine and doctor-patient communication, thereby improving medical accessibility in remote areas.
Based on the aim, we have established the following specific implementation items:
Develop an intuitive user interface and create a web-based system that supports physician operations. Implement core system functions, including appointment scheduling, patient record access, and basic remote consultation workflows. Establish an integrated patient data interface to help physicians understand the patient's overall condition, thereby improving diagnostic efficiency and decision-making quality.

1.4 Challenges

This project faced three main challenges: unexpected termination of cooperation, limited development time, and difficulties in obtaining back-end data resources.

First, the project began in June and was expected to end in early September. Under the original plan, we were to collaborate with Africa Virtual Hospital to complete the development of the Doctor Application. Although most team members lacked website development experience, the development work proceeded smoothly under the guidance of Africa Virtual Hospital in the early stages.

However, the partnership was terminated prematurely in mid-July, resulting in the team losing access to technical support and shared data, and significantly compressing the remaining development timeline. With only about one and a half months left for development, the team had to independently complete tasks such as system design and construction, leading to an extremely tight schedule.

Additionally, the team had originally planned to utilize existing data from Africa Virtual Hospital, such as patient basic information and medical records. However, due to the termination of the collaboration, our backend development team faced difficulties in accessing patient data and medical records, which are highly sensitive, thereby imposing some limitations on website functionality verification and data simulation.

Despite these challenges, our team adjusted the project scope, reallocated resources, and prioritized the implementation of core functions to ensure the platform's feasibility.

Chapter 2

Background

2.1 Relative Work

In many hospitals, patients need to wait for a long time just to have a short consultation with a doctor. This can be exhausting, especially for people who are already sick. In some places like the countryside, the problem is worse because there are not enough doctors or clinics [2]. Some people need to travel very far to get help, which is hard for old people or people with long-term illness.

During COVID-19, many doctors started using phone or video to talk to patients. In the UK, it went from 15% to 48% in just a few weeks [3]. It helped people talk to doctors from home and also saved time.

Our Smart Hospital system also uses phone and video consultations. We also have Health QA, where people can ask simple health questions and get advice more easily. These help people who live far away or cannot go outside, and they also make the waiting time in hospitals shorter.

Our system supports the United Nations' SDG Goal 3, which is about helping people stay healthy and live well [4]. Among all the targets, Goal 3.8 and Goal 3.4 are especially important to our project. Goal 3.8 is about giving basic and affordable health services to everyone. Goal 3.4 is about helping people with long-term sickness, like heart disease or mental problems. Our system lets them contact doctors or get advice online more easily, so they can get help earlier before the problem becomes worse.

2.2 Existing Solutions

2.2.1 Teladoc Health

Teladoc Health is a popular online medical platform[**?**] that offers services like video calls with doctors and support for mental health. It is used in many countries and is helpful for people

who find it hard to go to a hospital. But one problem is that it's not fully connected to real hospitals. This means doctors on Teladoc often can't see a patient's full medical records from other clinics or hospitals. As a result, some information might be missing, which can make it harder to give the right diagnosis or follow-up care.

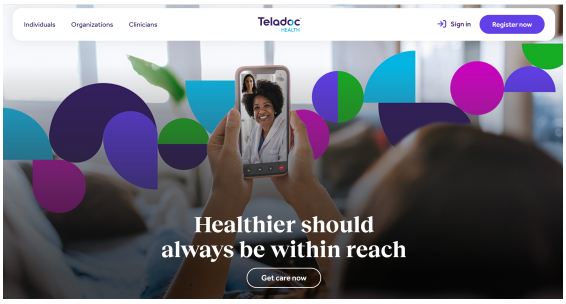

Figure 2.1: Homepage of Teladoc Health.

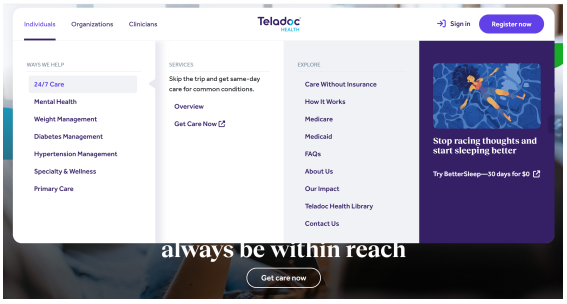

Figure 2.2: Service menu of Teladoc Health.

2.2.2 LINE Hospital Services

In Taiwan, many hospitals have their own official LINE accounts to provide online services. Patients can add the hospital's LINE to access booking and other basic functions. It is very easy to use, since most people in Taiwan already use LINE in their daily life. This makes it a common way for hospitals to offer simple medical services without asking people to download another app.

Figure 2.3: Screenshot of LINE services from Far Eastern Memorial Hospital, showing options like booking, announcements, and personal info links [1].

These features are quite easy to use. However, each hospital has its own design and menu. Some functions even open in separate websites. There is no unified system, so it can be confusing for some patients, especially older people or those not familiar with technology.

2.3 Requirements

The system is designed as a web-based platform for doctors, nurses, and patients to facilitate efficient clinical workflows and improve access to healthcare services. The main objective is to allow healthcare staff to manage patient information, record essential clinical data, and provide consultations remotely, thereby reducing unnecessary hospital visits. Patients are also supported with features to access their health records and receive guidance without needing to attend the hospital in person.

To ensure a functional and effective experience for hospital staff and patients, the system was designed to support a core set of features. These include secure user login and authentication for doctors, nurses, and patients; the ability to record patient vitals and view historical data trends; and an interface for remote consultation to minimise unnecessary hospital visits.

Drawing on the team's previous experience with similar healthcare platforms, including the Virtual Hospital Africa system, we referenced their approach as a conceptual foundation while adapting the design to our own project scope and requirements.

The system is initially populated with pre-existing mock patient data to facilitate testing and demonstration. In addition to these accounts, the platform supports new patient registration, enabling patients to create their own accounts and access the same core features, including secure login, health query submission, and medical record downloads.

Non-functional requirements include secure authentication with role-based access control, ensuring that only authorised users can access or modify clinical records. The system is designed for stable operation with fast response times to support real-time clinical workflows. In addition, the user interface is kept clear and intuitive to reduce training time for hospital staff. These system capabilities are closely aligned with the user stories presented below.

As a...	**I want...**	**So that...**	**Technical ability**
Patient	To ask health-related questions online	I can get medical guidance without visiting the hospital	2–3
Patient	To download my complete medical record	I can share it with a pharmacy or another healthcare provider	2–3
Nurse	To record patient vitals and update profile information	I can ensure accurate data is available for diagnosis	2–4
Doctor	To review patient history and vitals trends	I can make informed clinical decisions	3–5
Doctor	To add clinical notes and prescriptions	I can provide clear treatment guidance for the patient	3–5

Table 2.1: Smart Hospital User Stories

Chapter 3

Design and Implementations

Begins a chapter. Example: When the beloved cellist (Christopher Walken - outstanding) of a world-renowned string quartet receives a life-changing diagnosis, the group's future suddenly hangs in the balance: suppressed emotions, competing egos and uncontrollable passions threaten to derail years of friendship and collaboration. Featuring a brilliant ensemble cast (including Philip Seymour Hoffman, Catherine Keener and Mark Ivanir as the three other quartet members), it is a fascinating look into the world of working musicians, and an elegant homage to chamber music and the cultural world of New York. The music, of course, is ravishing (the score is the work of regular David Lynch collaborator Angelo Badalamenti): A Late Quartet hits all the right notes.

3.1 Methodology

3.1.1 Work Flow

3.1.2 Process

3.1.3 Front-end Tools

3.1.4 Back-end Tools

3.1.5 Testing Tools

3.2 Front-end Design and Implementations

3.2.1 Early Stage-Virtual Hospital Africa(VHA)

During initial discussions with the client about their requirements, the client pointed out that the current website's Patient Intake page contained too many information fields, leading to poor user experience and even many testers abandoning the form midway during testing (Figure 3.1). Based on this situation, the client designed a second version of the multi-step form interface

(Figure 3.2). The original form was split into separate pages (personal information, contact information, primary care, reason for visit), each with a progress indicator to guide users through the process.

During the programming and testing of the second version design, group members identified several issues that could potentially impact usability in actual interactions. We conducted internal team discussions and shared these issues with the client during our weekly design meetings. Ultimately, the client adopted our suggestions and finalized the third version design (Figure 3.3), with the following key improvements:

- 1. Added a left-side navigation bar to enable non-linear navigation

The original design relied solely on the top progress bar, requiring users to complete steps in a fixed order. We suggested adding a modular navigation bar on the left side, allowing users to freely jump to any section for modifications, thereby enhancing their sense of control and flexibility [1]..

- 2. Optimized field grouping and information hierarchy

We consolidated information such as name, gender, title, language, and national ID number into the "General" group and introduced a profile photo upload function on this page to add a patient profile photo capture/upload feature. This aligns the website's information layout with users' real-world information collection habits and aligns with the standard practice in hospital admission processes of "first collecting basic information and taking photos for record-keeping." Additionally, once the avatar upload is complete, a preview will be displayed immediately, and the centralized presentation of related fields will allow users to quickly confirm the accuracy of key information in a unified area, ensuring visibility of the interaction process [1]..

- 3. Unify navigation button layout

In the third version design, since we removed the top global navigation bar, users need clearer prompts for the next steps in the interface. Based on Nielsen's (1995) usability principles of "Visibility of system status" and "Match between system and the real world," we replaced the bottom buttons with 'Back' and "Next" as alternative navigation methods, clearly indicating the user's forward and return paths. This design reduces users' sense of disorientation during task flows, enhances the predictability of operations, and increases the certainty of task completion.

Regarding the second group: The client's requirements primarily focused on the patient profile page, highlighting several shortcomings in the current interface regarding information presentation and user experience. These include lack of detailed patient identification methods and information, absence of quick access points, unclear information structure, absence of direct editing functions, low efficiency in switching between information modules, and insufficient visual hierarchy in the interface (Figure 3.4). In response to the client's requirements, we

proposed several improvement suggestions, which were confirmed in subsequent meetings with the client, ultimately resulting in the design of the new version (Figure 3.5):

- 1. Enhance the patient information card: Add a profile picture, gender/age tags, patient status, quick contact button, download patient report button, and last edit time to the patient information card. This not only avoids healthcare staff having to make additional clicks or page switches to confirm patient identity and status but also addresses the issue of being unable to perform common operations directly on the patient profile page, enabling quick identification and efficient management of patient information.
- 2. Expand the patient information module and optimize the information navigation structure: Introduce more patient information modules in the Patient Profile, unify the naming and order of the top tab bar, and add a secondary menu on the left side, dividing the information into modules such as General, Primary Care, Contacts, Biometrics, and Insurance. This modular structure enhances the completeness of the information, allowing users to efficiently obtain the required data on a single page and reducing the need for frequent page switching or scrolling to find information.
- 3. Switch to editable forms: Present personal information in structured fields that support direct editing. This simplifies the information maintenance process, reduces operational steps, and enhances the user experience.

The third group of customers' needs were mainly focused on the Vitals page, and they pointed out that the current interface had many shortcomings in terms of data input structure and interaction experience, mainly including: all vital signs items were stacked in a single list, with no clear distinction between required and optional fields, making it difficult for users to quickly identify which fields to fill in first; the order of the fields did not fully match the clinical data collection process, and some commonly used data items were not placed prominently enough; the page lacked step-by-step navigation or process guidance, and users might not be able to confirm their progress(Figure 3.6). After internal discussions, we proposed improvement suggestions for these issues and reached consensus with the client during meetings, ultimately finalizing the new version design (Figure 3.7):

- 1. Grouped layout and priority adjustments

Vital sign information is divided into two main sections: "Required" and "Optional," ensuring that healthcare professionals prioritize the collection of critical data; the field order is adjusted to better align with actual clinical data collection practices (e.g., first entering height, weight, temperature, blood pressure, and pulse rate, followed by optional items such as blood glucose, oxygen saturation, and respiratory rate). [2].

- 2. Optimized operational workflow

Added Back/Next navigation buttons at the bottom of the page to replace the original single "Continue" button, allowing users to more intuitively control the progress of form completion and avoid omissions due to skipping or accidental operations.

- 3. Integration with patient information panel

Retained the patient profile summary and treatment timeline (Seeking Treatment) on the right side, ensuring that healthcare professionals can reference the patient's status and completed examination steps at any time during data entry.

These changes adhere to usability principles such as "Match between system and the real world," "Visibility of system status," and "Recognition rather than recall," reducing cognitive load, improving data entry efficiency, and minimizing operational errors. [1].

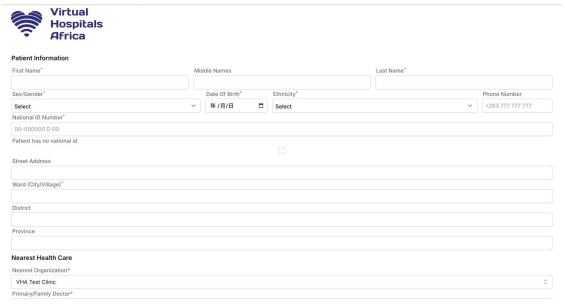

Figure 3.1: Patient Intake page – original version / user feedback context

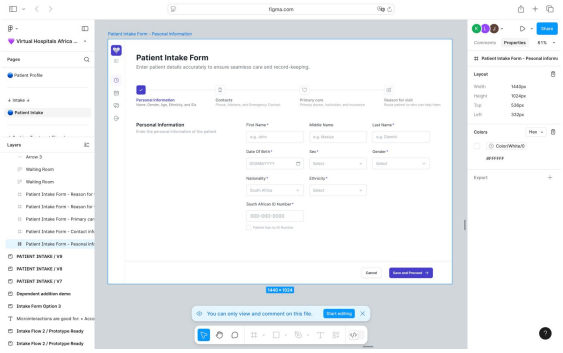

Figure 3.2: Second version multi-step form interface

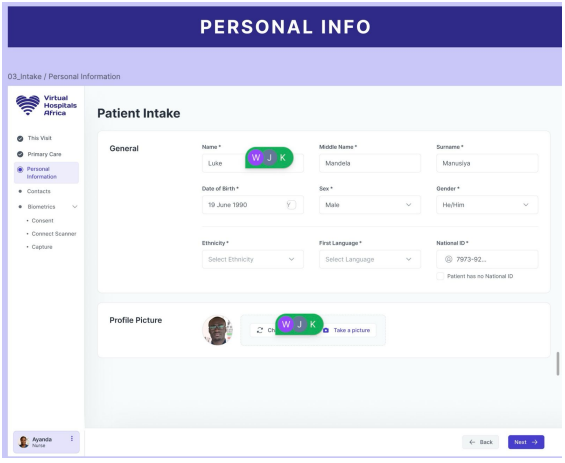

Figure 3.3: Third version with left-side navigation and unified buttons

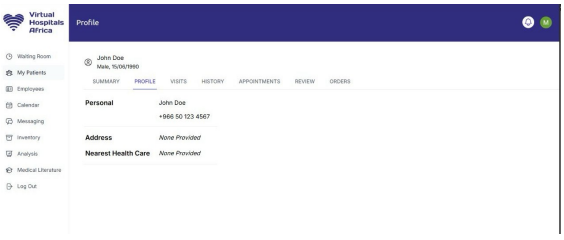

Figure 3.4: Patient profile page – issues in current interface

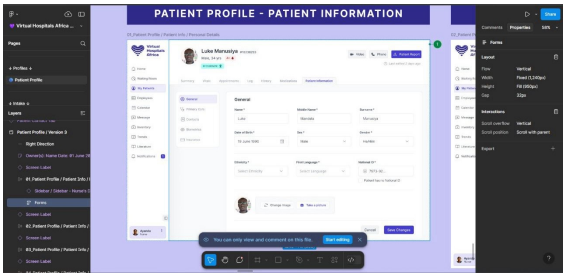

Figure 3.5: Redesigned patient profile with improved info card and modules

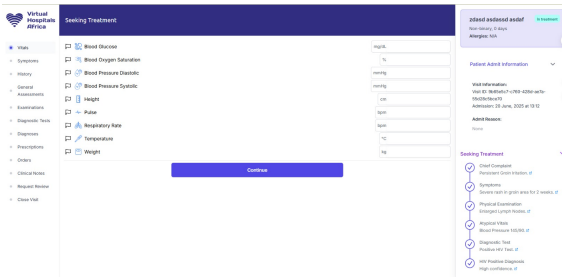

Figure 3.6: Vitals page – issues in original layout

3.2.2 Smart Hospital

3.3 Back-end Design and Implementations

Chapter 4

Evaluation and Testing

Begins a chapter. Example: When the beloved cellist (Christopher Walken - outstanding) of a world-renowned string quartet receives a life-changing diagnosis, the group's future suddenly hangs in the balance: suppressed emotions, competing egos and uncontrollable passions threaten to derail years of friendship and collaboration. Featuring a brilliant ensemble cast (including Philip Seymour Hoffman, Catherine Keener and Mark Ivanir as the three other quartet members), it is a fascinating look into the world of working musicians, and an elegant homage to chamber music and the cultural world of New York. The music, of course, is ravishing (the score is the work of regular David Lynch collaborator Angelo Badalamenti): A Late Quartet hits all the right notes.

Chapter 5

Conclusion

Begins a chapter. Example: When the beloved cellist (Christopher Walken - outstanding) of a world-renowned string quartet receives a life-changing diagnosis, the group's future suddenly hangs in the balance: suppressed emotions, competing egos and uncontrollable passions threaten to derail years of friendship and collaboration. Featuring a brilliant ensemble cast (including Philip Seymour Hoffman, Catherine Keener and Mark Ivanir as the three other quartet members), it is a fascinating look into the world of working musicians, and an elegant homage to chamber music and the cultural world of New York. The music, of course, is ravishing (the score is the work of regular David Lynch collaborator Angelo Badalamenti): A Late Quartet hits all the right notes.

Chapter 6

Reference

Bibliography

[1] Nielsen, J. (1995). *10 Usability Heuristics for User Interface Design*. Available at: `https://www.nngroup.com/articles/ten-usability-heuristics/`

[2] NN Group. *Web Form Design*. Available at: `https://www.nngroup.com/articles/web-form-design/`

Appendix A

Appendix A

Begins an appendix

Bibliography

[1] F. E. M. Hospital, *Official line account.*
https://line.me/R/ti/p/@femh, 2025.
Screenshot taken by the author.

[2] International Labour Organization, *Decent work for rural health workers.*
https://www.ilo.org/global/topics/economic-and-social-development/rural-development/WCMS_768518/lang--en/index.htm, 2021.
Accessed: 2025-08-02.

[3] N. Trust, *Digital primary care: Where next?*
https://www.nuffieldtrust.org.uk/research/digital-primary-care-where-next, 2022.
Accessed: 2025-08-02.

[4] United Nations, *Ensure healthy lives and promote well-being for all at all ages.*
https://sdgs.un.org/goals/goal3, 2022.
Accessed: 2025-08-02.