

# An Improved Framework of Healthcare Supports System for the Treatment of Dementia Cases

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**Abstract:** This research proposes an improved framework that would support the healthcare services and attention given to dementia patients. The paper shows the design and implementation of a web-based application that demonstrates the proposed framework. This study was necessitated by the observed flaws and weaknesses in the current manual technique of handling dementia cases in care homes which are plagued with loss of records, time wastage in retrieving records, data insecurity, user entry and data management errors, among others. The system design was realized using the unified modeling language (UML) on EdrawMax. The frontend implementation was done using HTML5, CSS3, and JavaScript, while the business logic was achieved using PHP, and the Database was designed with MySQL and managed through PHPMyAdmin. The system was tested by medical practitioners and dementia patients in a select care home. Other tests on browsers' compatibility and platform interoperability were successful. The result of the study advances technical knowledge in developing medical expert systems using web 2.0 technologies, and promotes academic inquiry in the domain. The demonstration of the framework shows an improvement on the existing techniques which use quasi-automated approach. The proposed model is suitable for supporting efficient management of data of dementia patients.

**Index Terms:** Caregivers, Care Home, Dementia Cases, Healthcare Application, Improved Framework, Patients.

## **1. Introduction**

Dementia is a psychiatric condition (set of symptoms) triggered by multiple illnesses [1]. It is further described as diverse brain disorders or acquired deterioration in thinking and memory because of brain disease resulting in notable impairment of social, personal, or occupational purposes [2]. The disease affects other functions of the brain such as communication, memory, personality, mood, orientation, language, calculating ability, judgment, comprehension, reasoning, learning capacity, and information processing [3].

Pavisc, Suarez-Gonzalez and Pertzov [4] inform that short-term memory is the common challenge of people with dementia. Oftentimes they do not remember things they have just done or said, although they can recollect occasions that took place some years back. Their perception of location and time is of course gone, rendering it impossible to use new terms, absorb new knowledge, and do new stuff. As the dementia stage progresses, victims require assistance to carry out common tasks of daily living, such as bathing, dressing, washing, eating, and toileting. Oftentimes, there is a severe behavioural challenge that makes them uncontrolled and uncommunicative. At this stage, they require 24-hour

monitoring and care. Dementia may lead to sudden death, but it is not the actual cause of death. If people with dementia are properly taken care of, they can live with the situation for many years.

Koumakis *et al.* [5] assert that there is an urgent need to improve dementia care quality by designing a framework and developing a web application to increasingly gather information and artifacts about patients, their history and interests, diagnosis, and treatment, care, and support, and making this information available when needed. Efforts have been made to develop solutions for managing dementia cases such as the COGKNOW, Context-aware, Alzheimer's Caregiver Internet Support System (ACISS), and Net-book Specific, used as Cognitive Help, Reminders, Health and Activity Monitoring, and Socialization respectively. These systems have pertinent flaws majorly in usage time, accuracy, ease of data presentation and management, and user-friendliness, as highlighted in Table 1 in the next section.

Therefore, the objective of this research is to develop an application that is simple, efficient, secure, and cost-effective to deliver real-time updates to care home administrators, caregivers, and patients to make their jobs more enjoyable and less frustrating. [6] proposed that an application-based method of data management is cost-effective and would improve the quality of treatment and care, minimize medical mistakes, and enhance communication between caregivers and patients. It would also boost information storage, update, retrieval, readability, reliability, and data quality [7]. The study significantly enriches modern approaches to dementia care. It will benefit patients, caregivers, healthcare stakeholders, and researchers.

## 2. Related Work

Dementia is a serious and rising health issue worldwide [8]. Despite an uncertain eventual solution, delivering high-quality and cost-effective treatment and care over what is always needed for a longer period is and will continue to be a significant issue for caregivers [9]. Healthy life for people living with dementia in care homes has been the concern of researchers, practitioners, and policymakers [10]. Efforts in recent times are centered on how to manage patients' information and data to drive better care, however, the challenge associated with these efforts involves but is not limited to the cumbersome nature of the data which results from inadequate entry or redundancy of available data of patients' lived experiences and biographies when they are needed for policies or research [11].

According to [12], one challenge identified in dealing with dementia cases is that too many of the cases are under-reported, hence, the need to have an effective and efficient reporting system that can capture the real-time data needed for patients' experiences improvement. Although the information or data obtained from people living with dementia requires adequate storage for future use, the current practice (paper-based) of managing patient records in care homes is not efficient for such voluminous data. This approach has continued to present numerous drawbacks and challenges to caregivers, patients, and administrators such as data replication, data discrepancy, data insecurity, and un-updated information making it difficult to trace the histories and flow of prescription data of patients, therefore, hampering prognosis outcome [13].

People with dementia behave differently. As such, the effect of dementia at each of the stages hangs on the type of dementia the individual has. According to [14], there are more than 100 confirmed types of Dementia, nevertheless, most of them are very rare. The four main (common) types of dementia found in clinical practice are Alzheimer's disease, vascular dementia, frontotemporal dementia, and dementia with lewy bodies, which account for 90 to 95 percent of all cases. This study does not limit itself to any dementia. The proposed model would satisfy all and any.

Szzechowiak, Diniz & Leszek [15] reported that there is no single cause of dementia or a cure for it. Rather, it is a progressive disorder, with deterioration likely to occur in all areas and people at the age of 90 and above are highly at risk of developing dementia than those at the age of 60. This argument agrees with the publication of [16] where they emphasize that various kinds of dementia have diverse possible causes. The authors noted that dementia is generally found in elderly individuals, but age is not an indicator of the true cause of dementia.

The World Health Organization [17] informs that dementia has notable economic and social implications concerning the rates of medical services, informal treatment, and direct clinical care. In 2015, the total global societal cost of dementia was estimated to be US\$ 818 billion, equivalent to 1.1% of global gross domestic product (GDP). The overall expense as a share of GDP varied from 0.2% in low- and middle-income countries to 1.4% in high-income countries.

Although time has not provided a solution for dementia, it has brought modern medical applications (Table 1) that can alleviate the strain of treatment and help medical practitioners to execute their task in a more relaxed and safer manner [18] which in return promote the quality of healthcare among dementia patients.

Table 1. The Medical Software for Dementia

Medical Software for Dementia	Application Area	Use	Pros	Cons
COGKNOW [19]	Cognitive Help	For an innovative solution to cognitive reinforcement from a services perspective such as selection and engagement in a choice program	Increases the quality of life and independence and elongates the period individuals with dementia can live within their home environment.	Suggestions indicated that reminders should be more personalised and should support personal configuration.
Context-aware [20]	Reminders	For reminding people suffering from mild dementia to perform their daily activities in time and in the correct manner	Moderates memory impairment of dementia patients and improving their independence level thereby minimising the burden on caregivers	The occurrence time of disruptive activity, such as answering a phone call, cannot be predicted. It may disrupt the pre-planned activity.
Alzheimer's Caregiver Internet Support System (ACISS) [21]	Health and Activity Monitoring	For monitoring of health and activity of people with dementia	Offering decision making, clinical, and emotional support to family caregivers of patients with Alzheimer's disease.	The privacy of the patient is not taken into consideration
Net-book Specific [22]	Socialisation	For improving the performance of people with dementia in social activities engagement	Enable patients diagnosed with Alzheimer's disease to independently make phone calls to various partners, like friends, family members, and caregivers	Time-consuming in selecting call contacts independently, support is still needed by the dementia patient in this aspect.

The justification of this research is that many applications developed to assist people living with dementia as reviewed in this study focus on cognitive help, reminders, health/activity monitoring, and socialisation without making provision for information storage. The proposed system enables patients to upload personal data, make complaints, and receive feedback from their caregivers. The caregivers can also access the patient's record for decision-making. Adopting this system would enhance effective performance by caregivers thereby improving the quality of healthcare for people with dementia.

### 3. Methods

#### 3.1 System Design Technologies

The technologies used in designing the framework and developing the application are HTML, CSS, JavaScript, PHP, MySQL, and XAMPP. The database was first designed using MySQL. The justification for choosing MySQL includes Server reliability and compatibility with numerous applications programming interfaces (APIs) [23]. Next, the project framework (CodeIgniter) was set up to help in writing and organising the programming code. The rationale for adopting this framework includes Highly Secure [24]; Faster Execution Time [25]; and Easily Management of Errors [26]. Thereafter, the front-end (client-side) was designed to meet the users' needs using HTML5, CSS3, and JavaScript. The rationale for selecting these tools was to easily determine the content, appearance, and responsiveness of the webpage [27]. The server-side (back-end) was designed using PHP to enhance the retrieval of data. The rationale being that the PHP code can be executed on all major platforms and can interact with numerous database languages including MySQL [28]. XAMPP server was then activated and some SQL queries were written to retrieve the desired information.

#### 3.2 Class Diagram

The class diagram lays the framework for all subsequent design and implementation tasks. It is a technique for defining various data types, proves the presence of object classes and their fixed linking in a logical flow of the system [29]. The class diagram for this study includes the following classes: Admin, Patients, Doctor, Nurses, and Carers. Each class is responsible for managing the operations of that class. For instance, the admin class manages all the operations of admin, while the patients' class manages all the operations of patients. Fig. 1 is the representation of the class diagram.

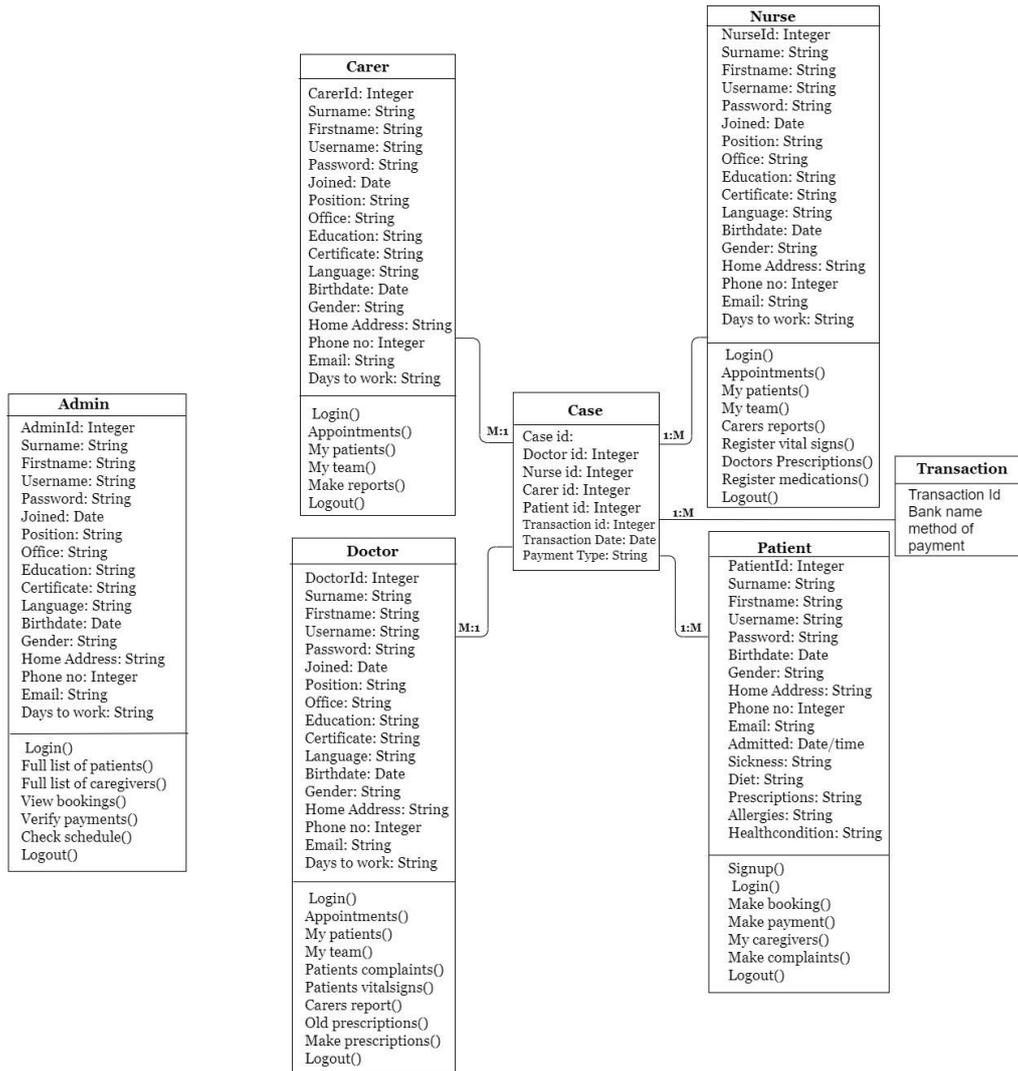


Fig. 1. The class diagram for the proposed system

### 3.3 Use Case Diagram

A use case diagram is a visual representation of the user’s interactions with the system. In this system, the users are the Admin, Patient, Carer, Doctor and Nurse. The admin, for example, can assign patients to a carer; the patient, on the other hand, can submit complaints that are available to caregivers; a carer can, among other things, see the patients who have been allocated to him and submit a report after the shift. Following a successful login, a doctor’s tasks include reviewing patient complaints and writing prescriptions. The nurse can collect and record a patient’s vital signs, as well as the drugs dispensed. The use case diagram for the proposed system is as shown in Fig. 2.

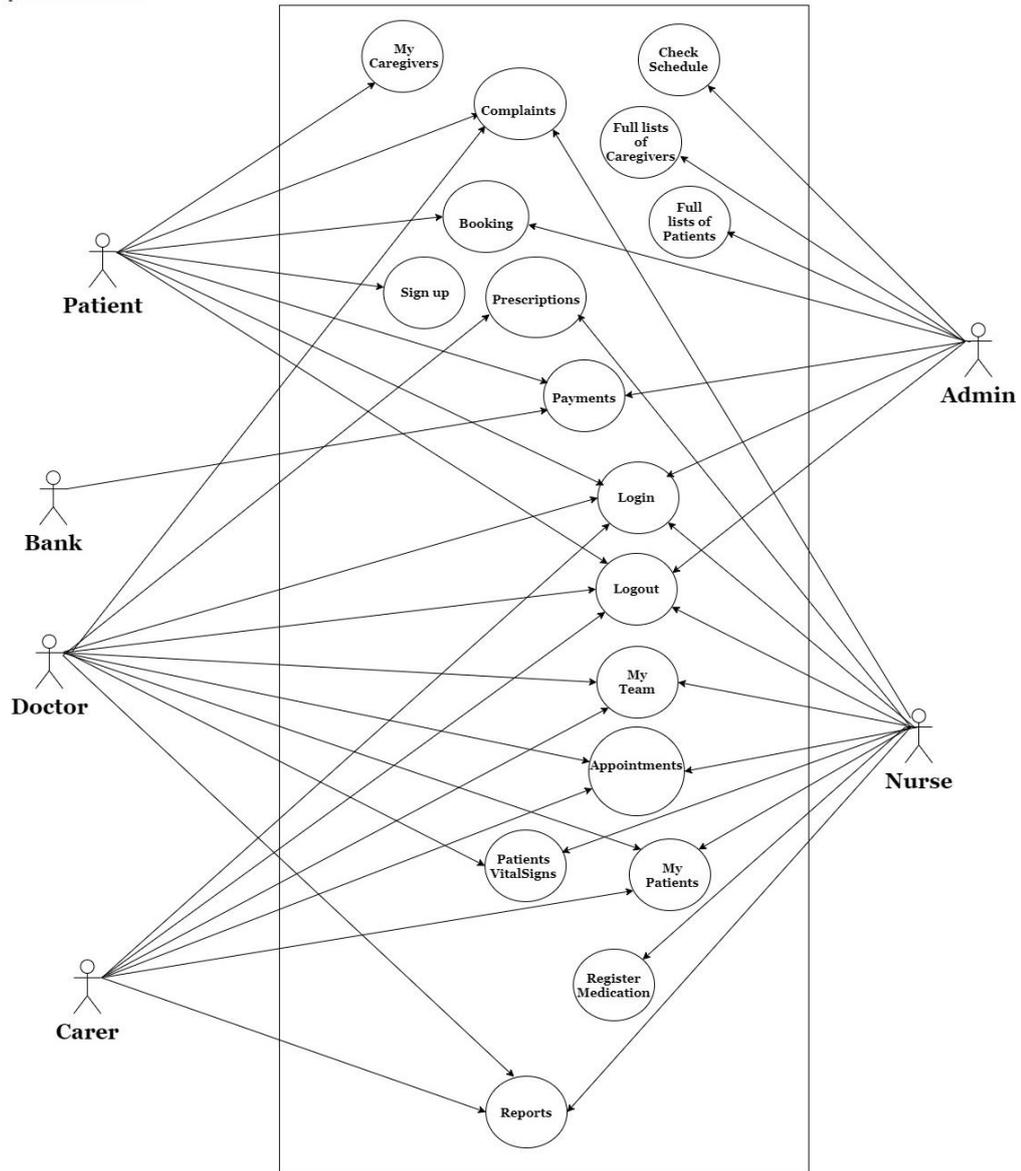


Fig.2. The use case diagram for the proposed system

### 3.4 System Flowchart

System flowcharts show how information flows through a system and how decisions are made to regulate occurrences. Therefore, at the start of the sequence in this system, a new user registers in the system to receive login credentials, which are generally a username and password. After successful registration, the information is transferred to the database for storage, which qualifies the new user as an existing user. Logging into the system is the first step for an existing user. The system then verifies the user's credentials to see if they are valid or not. If the login is successful, the user will proceed to perform the desired task and then exit. The flowchart for the proposed system is as shown in Fig. 3.

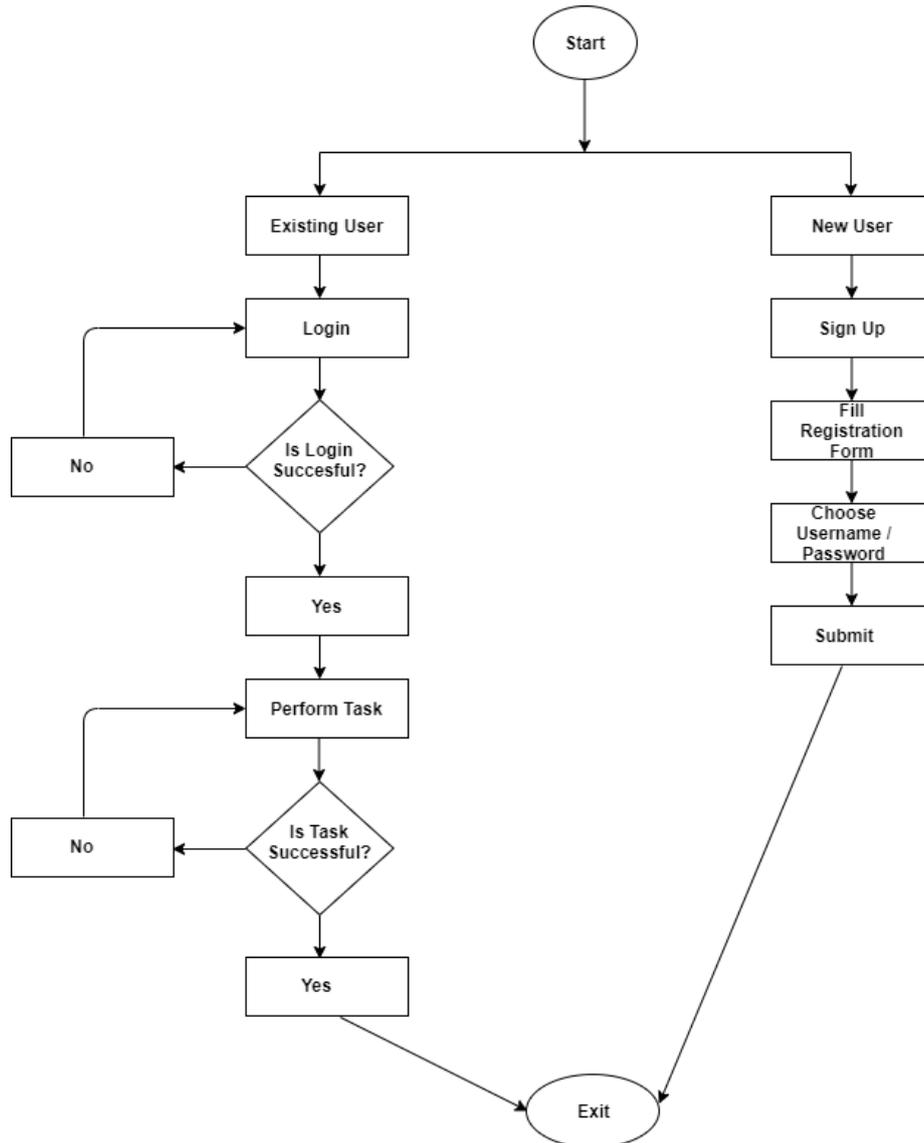


Fig.3. The system flowchart

### 3.5 The Proposed Framework

The research framework as shown in Fig. 4 demonstrates the flow of information from different terminals. The main users of the system are the admin, patients, and caregivers (doctors, nurses, and carers). The usage of the system requires a computer system, internet connection, and a web browser. The framework offers an interface where the users can sign up to obtain their login credentials to further access the system resources. Patients can make complaints and receive feedback; Caregivers, for instance, carers can log any observation or assistants given to a patient; nurses can register patients' vital signs and medication; while doctors can access carer's reports, patient's complaints, and vital signs and make prescriptions.

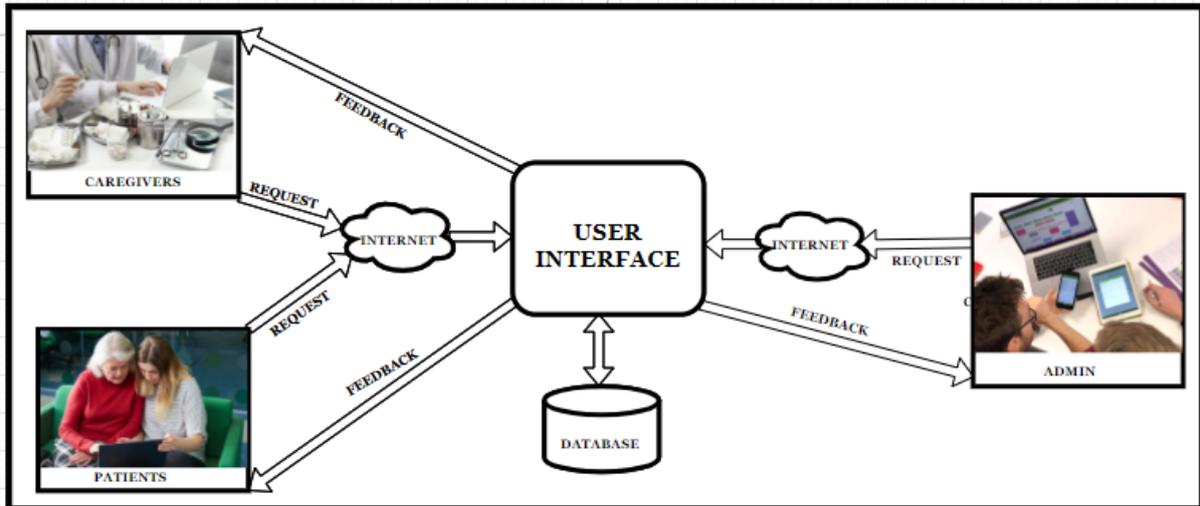


Fig.4. The proposed framework

### 3.6 Database Design

To complete the flow of data and data processing tasks in this study, a database named “dementia care” was created with thirteen (13) tables. Each table was designed to meet the needs of the user. The thirteen (13) tables created are patient, admin, carer, nurse, doctor, booking, vital signs, complaint, payment, report, patient-doctor, patient-nurse, and patient-carer. The relationship between the tables is established. For instance, the patient table is connected to the doctor table through an extension table patient-doctor which shows that the patient relationship with the doctors is many to many. Also, the relationship between the patient table and the payment table shows one-to-many relationships. The tables' relationships link tables and help in retrieving the desired information from the database. Fig. 5 shows the entity-relationship diagram of the database.

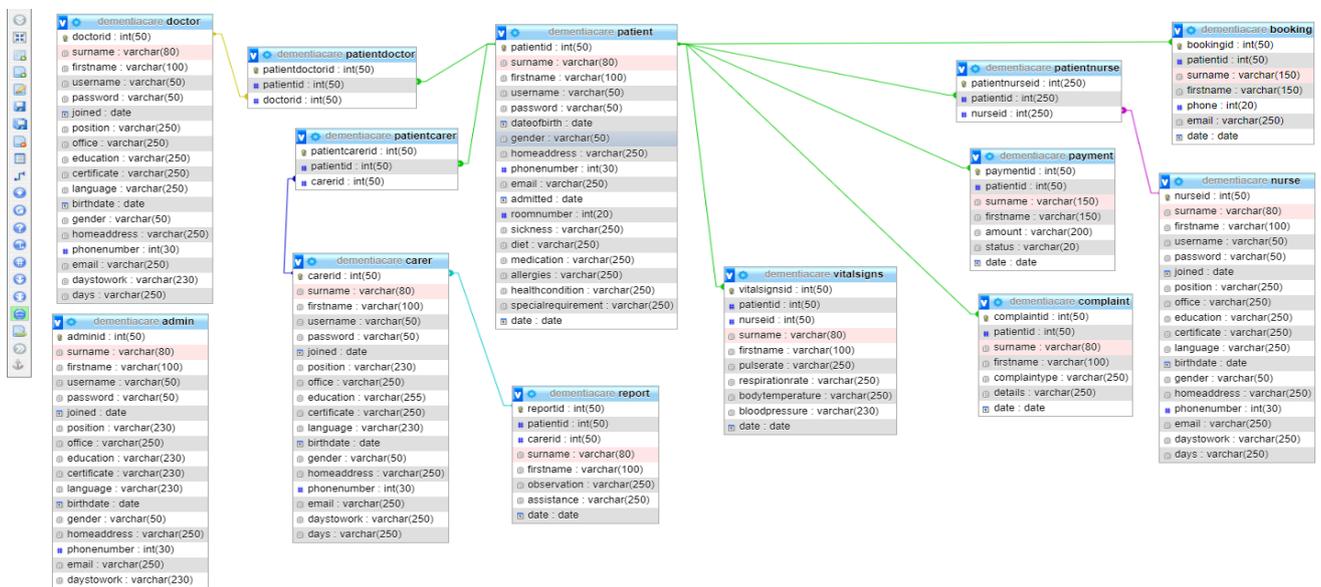


Fig.5. The entity relationship diagram of the database

## 4. Results and Discussion

This section presents and discusses the results of the implementations. The application for this study comprises of five actors: Admin, Patient, Carer, Nurse, and Doctor. To begin using the application, new users sign up to get registered in the system. Once successfully registered, login credentials usually the username and password are issued to the users which enable them to access the services available for them. The connection of the user interface to the

database ensures information centralisation, unlike the paper-based approach that separates information into different storage thereby causing data inconsistency, replication, insecurity, and difficulty in updating information. The proposed system promotes easy communication among caregivers and patients. Also, data protection is ensured because users are uniquely identified and authenticate before granting access to the system.

Furthermore, once the admin has successfully gain access into the system, the modules designed for the admin enables him to verify patient’s payment to ascertain if it is legitimate. Once the invoice is verified as genuine, the admin assigns caregivers (carer, nurse, and doctor) to the newly registered patient which now created a communication channel between the patient and caregivers. Fig. 6 shows an instance of patients’ allocation to a doctor for treatment. There are a total of five (5) doctors and twenty (20) patients. Doctor 1 treats patients 1, 5, 9, and 11; Doctor 2 treats patients 2, 8, and 12; Doctor 3 treats patients 3, 6, 15, 16, and 20; Doctor 4 treats patients 4, 10, 13, and 18; while Doctor 5 treats patients 7, 14, 17, and 19.

Patient ID	Patient Lastname	Patient Firstname	Doctor ID	Doctor Lastname	Doctor Firstname
1	Sylvester	Patience	1	Ntuen	Mkpouto
5	Sena	Bassey	1	Ntuen	Mkpouto
9	Kenedy	Rose	1	Ntuen	Mkpouto
11	Lampard	Joy	1	Ntuen	Mkpouto
2	Shark	Martin	2	Harvest	Kely
8	Tomy	Festus	2	Harvest	Kely
12	Dan	Olory	2	Harvest	Kely
3	Peter	Owo	3	Abas	Pepe
6	Deputy	Cynthia	3	Abas	Pepe
15	Dike	Esther	3	Abas	Pepe
16	Walter	Bari	3	Abas	Pepe
20	Paul	Imelda	3	Abas	Pepe
4	Mathais	Edith	4	Akan	Idara
10	Celestine	Angel	4	Akan	Idara
13	Boris	Great	4	Akan	Idara

Fig.6. Patients’ allocation to doctors for treatment

Also, patients can among others make complaints that are accessible by the caregivers. The Complaint module enables patients to lodge any complaints to enhance quick intervention from their caregivers.

Fig. 7 shows the interface that enables patients to make complaints. Part of the responsibilities of a carer is to provide support to patients allocated to him and make reports at the end of the shift (Fig. 8). The reports include the assistance given to patients, observations made, and any complaints from patients. The carer’s reports are accessible by the doctors and nurses. The nurse collects and reports the patient’s vital signs (Fig. 9). The doctor uses the carer’s report, patient’s complaint, and vital signs to make decisions and prescriptions for patients. The nurse then uses the prescription as a guide to dispensing medications to patients and registers it in the system for future reference.

Patient ID	Last Name	First Name	Complaint Type	Details	Date
1	Sylvester	Patience	Fever	Headache and High Body Temperature	2020-09-09
2	Shark	Martin	Restlessness	Agitating and unable to sleep	2020-08-03
3	Peter	Owo	Diarrhea	loose and watery stools	2020-08-27
4	Mathais	Edith	Headache	Persisted for several days	2020-09-11
5	Sena	Bassey	Vomiting	Happens often after meal	2020-09-18
6	Deputy	Cynthia	Sow	Mouth sow for about three days	2020-08-15
7	Mondy	Cal	Fever	Headache and high body temperature	2020-08-18
8	Tomy	Festus	Stomach upset	Complaining of pains for about 2 days	2020-07-31
9	Kenedy	Rose	Restlessness	Wandering and agitating	2020-08-15
10	Celestine	Angel	Diarrhea	loose, watery stools	2020-09-23

Fig.7. The interface that enables patients to make complaint to caregivers

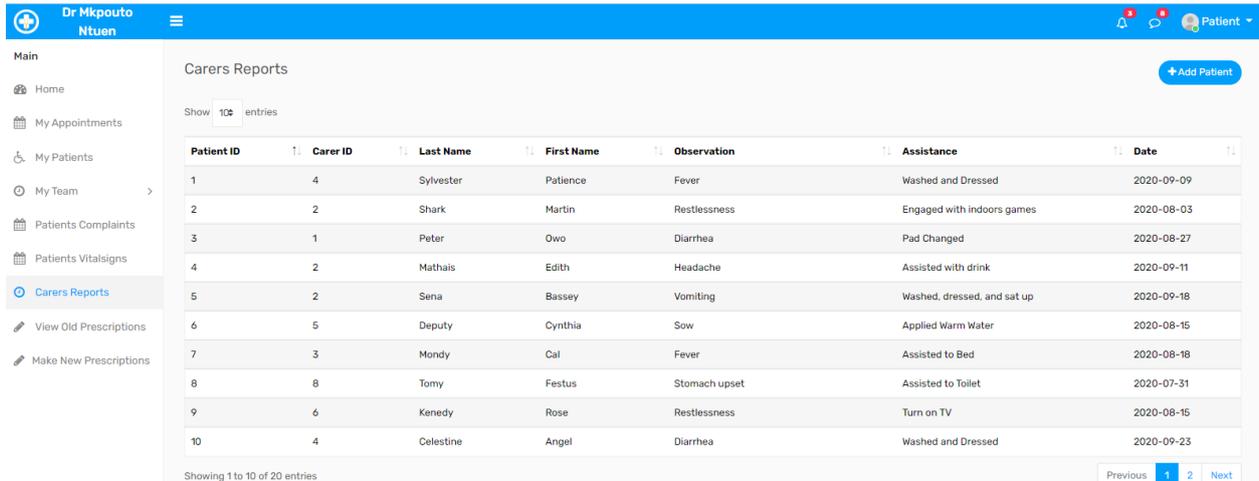


Fig.8. The interface that enables carers to make report after a shift.

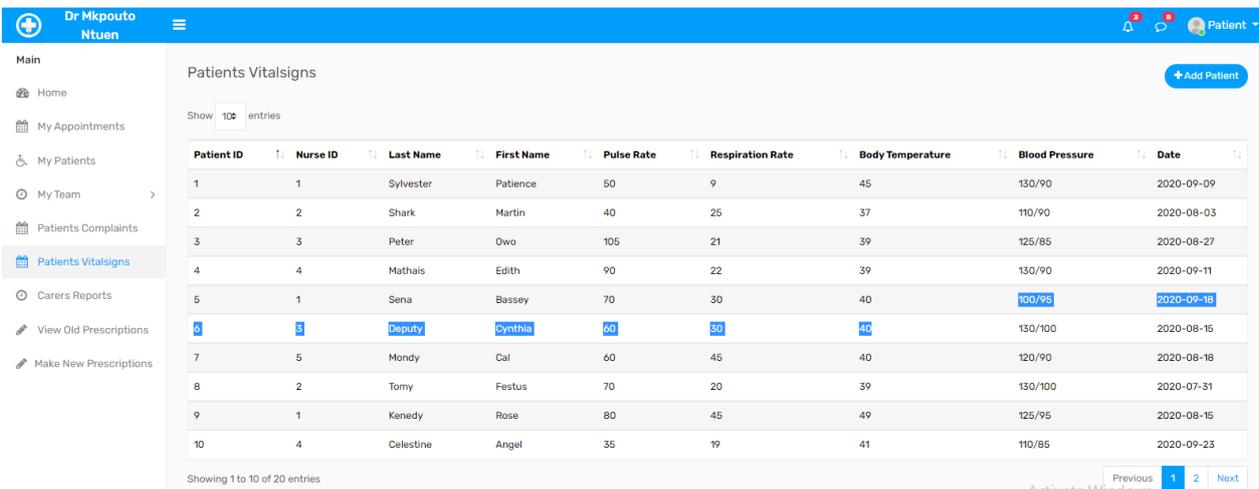


Fig.9. The interface that enables nurses to report patients’ vital signs

After a successful development of the application, a Cross-browser Compatibility Testing (CCT) was performed on the system to ensure that the behavior and user experience were consistent across all browsers, devices, and platforms. This also ensured that the features of the application such as code validation, performance, responsive design, and user interface inconsistencies worked perfectly. Chrome, Opera, Firefox, and Edge were used to evaluate the application that was built in this study. Table 2 displays the outcome.

Table 2. The result of the CCT test

S/ N	Interface	Features	Scenario	Expected Output	Actual Output	Result	Chrome	Firefox	Opera	Edge
1	Users	Login	Wrong username or password	Error message	Invalid username and password	Pass	✓	✓	✓	✓
	Users	Login	Correct username and password	Load the user’s interface	User’s interface loaded	Pass	✓	✓	✓	✓
2	Patient	Make Complaint	Click make complaint	Show interface	Interface is shown	Pass	✓	✓	✓	✓
3	Admin	Make Schedule	Click schedule	Show schedule	Information displayed	Pass	✓	✓	✓	✓
4	Carer	My Patients	Click my patients	Display Patients assigned	List of Patients showed	Pass	✓	✓	✓	✓
	Carer	Make Report	Click make report	Show interface to file reports	Interface is shown	Pass	✓	✓	✓	✓

5	Nurse	Register Vital Signs	Click register vital signs	Launch interface to file vital signs	Interface displayed	Pass	✓	✓	✓	✓
	Nurse	Register Medication	Click register medication	Display interface to log medications	Interface is shown	Pass	✓	✓	✓	✓
6	Doctor	Check Complaints	Click patients' complaints	Show patients complaints	Patients complaints showed	Pass	✓	✓	✓	✓
	Doctor	Make Prescriptions	Click on make new prescriptions	Launch interface to log prescriptions	Interface launched	Pass	✓	✓	✓	✓

## 5. Conclusion

The lack of a firm information system to serve patients and caregivers has led to inconveniences in the care home. The paper-based method and quasi-automated techniques of recording, accessing, and exchanging information between caregivers and patients is a tedious task, time-consuming, repetitive process which may result in exposure or loss of sensitive information. The implementation of a web-based application in the care home is vital to the effective handling of information, and the proposed framework would bring about a significant change. The application has fulfilled the key targets set for the project. The application offers several interfaces for the completion of tasks by Admin, patients, and caregivers (Doctors, Nurses, and Carers). For instance, patients can make complaints and receive feedback; Carers can log any observation and assistant rendered to patients; Nurses can report patient's vital signs and document medication dispensed; Doctor can access patient's complaints and vital signs for decision making and prescriptions, while the Admin can schedule caregivers for duty.

Having one application that can handle these tasks is expected to dramatically improve the quality of treatment and care for patients by effectively decreasing the time for caregivers to make decisions. The application does not need installation on a separate computer; therefore, it is also expected to be easier to use. With further improvements, the application would become a powerful guide for patients with dementia being managed more effectively. While the study identifies in literature a few systems proposed for dementia problems, the healthcare facilities chosen as the case plant for this study uses a paper-based and quasi-automated system, managing data majorly on electronic spreadsheets. This made benchmarking our model with the existing system difficult. However, our system was subjected to testing by the medical personnel in the facility with their live dataset and found a good replacement of the current solution.

This paper, thus, advances academic knowledge in leveraging web 2.0 technologies to enhance data management in the healthcare sector by reducing paper-based bookkeeping techniques. It attempts to promote scientific inquiry into the role data management plays in the treatment of dementia cases in particular, with huge potentials for adoption in other cases and domains. Future work will consider the implementation of appropriate machine learning algorithms to improve the accuracy of the proposed framework. Publicly available dataset of dementia cases shall be used for training and testing such as algorithms.

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