DEVELOPMENT OF A MODEL FOR MANAGING CRITICAL PHARMACEUTICAL PRESCRIPTIONS

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OLUBODE FRANCIS LAWANSON

Postgraduate Student, Department of Computer Science,

Afe Babalola University, Ado-Ekiti, Ekiti State, Nigeria.

lawansonof@pg.abuad.edu.ng

+2348039122080

ALABI BELLO O. (Ph.D.)

Department of Computer Science,

Afe Babalola University, Ado-Ekiti.

Ekiti State, Nigeria.

bellooa@abuad.edu.ng

+2348166360838

OPANI AWEH M. (Ph.D.)

Department of Computer Science,

Afe Babalola University, Ado-Ekiti.

Ekiti State, Nigeria.

opaniaweh@abuad.edu.ng

+2348039462401

Abstract

Objective: *prescription by medical personnel is a complex phenomenon influenced by various factors. Most of the existing studies in the area of drug prescription explain the process of decision-making by physicians via the exploratory approach rather than a theoretical one. Therefore, this study observed that despite the multiplicity of pharmaceutical drug prescription* *systems (prescription errors) are still prevalent this study observed that a significant factor responsible for the occurrence was the inability to take into cognizance critical factors why carrying out a prescription in the course of such prescription's critical factors such as existing medication the patient is currently on, physiological factors, contraindications, patient biodata, and drug interactions. To address this problem,*

Materials and method*: the study designed a prescription system that incorporated these enumerated critical factors by developing a mathematical model that incorporated those factors as a set and incorporated in a fuzzy set that guards the prescription system to arrive at an optimal outcome. The developed system was then implemented tested and observed to be functional,*

Result*: The research was carried out by getting and comparing data from different pharmacies and hospitals in Nigeria; the output was used in building a model on Which the proposed system is based. ReactJS was used in the implementation of Graphical User Interface, PostgreSQL was used as the database for data warehousing, and ChartJS was used to show the interaction graph between drugs after the system was used to determine the level of severity of drugs and also categorize interaction.*

Conclusion *reviews of subsisting electronic prescription systems were Carried out. Based on the knowledge gained, a more encompassing prescription system that considers the multiplicity of critical factors in the course of pharmaceutical prescriptions was developed. The test runs conducted using this developed system showed that better care from the perspective of pharmaceutical prescriptions could be readily archived from the traditional approach to prescription handling and created a model to manage critical pharmaceutical prescriptions.*

Keywords [phamaceutical prescriptions, combinational therapy, critical factors, fuzzy model.]

1. Introduction

Inaccuracy and imprecision are problems that characterize the traditional medical diagnostic method, which has caused much damage and claimed lives [1]. Difficulties may occur at any part of the prescription process, from the moment the prescriber chooses drug treatment to the moment the patient receives that treatment. [2] [3] [4] Stated that Medication errors can occur in any sector of the health care system, from the prescription of the drugs to the administration for final use by the patient. The simple truth is that many of these miscalculations are preventable. Some precautions to be taken. includes clear handwriting, the correct spelling of medicine names, formulation, and strength of medicines should be quoted clearly, the abbreviation of medicine names should be avoided, and leading zero should always be used. [5] [6] [7]

Prescription writing is a vital task that places the responsibility towards the clinical care and safe monitoring of the patient, with the prescriber thus also carrying legal implications. A prescription is a written order of medication to diagnose and treat a specific patient directed by a physician. The art of prescription writing is ancient in origin; contemporary practices are more simplified and systematic [8], [9].

Prescription of drugs can be grouped into an intellectual part—decision making, i.e., interactions, knowledge of diagnosis, and contraindications, and a technical part which includes communication of essential information, i.e., drug name, dose, the form of administration [10] [11], [12].

Proper management of medical prescriptions is a veritable means of avoiding medication errors, and electronic prescription systems are increasingly being introduced to address this problem. Electronic prescribing systems can act as mediating (compare and check) systems preventing other Medication errors such as drug interactions [13].

Nowadays, medical prescriptions are increasingly being managed by computer-related technologies. These systems are primarily based on the principles of artificial intelligence. They are designed not just to diagnose based on symptoms but also to prescribe treatments based on such [1,14]

The concurrent usage of multiple drugs is often associated with drug-drug interactions, representing an essential category of adverse drug reactions [15][16]. Since information on drug interactions is vast in volume, scattered in the literature, and still increasing, it is impossible to check potentially dangerous drug combinations thoroughly by manual method, mainly when a patient is administered many drugs.

The motivation for this study is that it will minimize the incidence of medical errors and their associated fatalities. It can also serve as a support for teaching and guiding medical practitioners and prospecting medical practitioners.

2. Literature Review

[17][18][19][20] described how "fuzzy logic" systems could be used to formalize approximate reasoning in medical diagnostic methods. The conversion from this unclear nature into a crisp real-world outcome causes the loss of precision.

The potential implementation of fuzzy artificial networks in medicine is also analyzed.

[21][22]explained that Prescriptions are a fundamental task performed by health professionals; [23] when prescriptions are not properly made or contain errors, the consequences can be irreversible damages, including death. The present article attempts to gain insight into the thoughtful and deliberate prescribing method to prevent medication errors. [24][25] [26] [27] The condition for error-free prescribing must be warranted. While writing the prescriptions, it must be ensured that it is appropriate and in the patient's best interests. Additionally, motivational prescription writing programs, patient understanding, pharmacist education, and periodic prescription audits may encourage error-free prescribing.

[28]explained that interaction describes the biological activity that results from the presence of several drugs at the same time. Such situations occur in numerous clinical cases: [29]severe clinical situations require administering different drugs to combat multiple therapeutic indications although, in many cases, combinations of these drugs are not designed to focus on synergies; hence the drug interactions need to be assessed.

The effect of a medication may be augmented by another drug that does not alter the effect when used individually [30] [31].

In many cases, multiple drugs administered will exhibit specific forms of synergistic, antagonistic interactions or none at all. Methods for determining the number of drug interactions are thus an essential tool in pharmacology [32][33].

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Computational intelligence has been used recently in several complicated medical issues by developing Intelligent systems. [34] [35][36] And fuzzy logic is a robust system for decision-making programs, for instance, structure classification systems and expert systems. Some medical expert systems have already been making use of the fuzzy set theory. The diagnostic decisions that medical authorities make rely on the familiarity, experience, knowledge, capability, and understanding of the medical scientist. It is not easy to diagnose a problem without any mistake, significantly when the system's complexity increases. Fuzzy logic provides powerful techniques for handling complex issues [37] [38] [39] [40]. diverse medical systems have already been developed based on the fuzzy logic model and have already been applied to diagnoses and treatment of patients [41] [17] [42] [43]. Fuzzy logic delivers a means for capturing the instinctive decision-making process in humans into an algorithm suitable for computer implementation [44] [45] [46]

[47] [48]. Studies have been able to use open-source tools to develop a system that provides easy access and storage of an extensive database of people living with HIV/AIDs that are mined to predict the disease

In recent times, fuzzy logic-based systems have been deployed in the area of medicine; [49], most commonly in circumstances where precision is valuable, such as kidney transplants, diagnosis of ailments, drug prescription, etc. [50] [51] [52] [53] [54]

. Now, researchers are using machine learning with data mining to automate medical recommendations. [55] [56]The risk of prescribing incorrect medicine can decrease as many deaths are caused due to the wrong medication,

Some of the edges of fuzzy logic are that it provides flexibility for reasoning by considering the uncertainties of the situation. Especially where there is too much uncertainty at the outset, When the scope is too narrow and important variables are inadvertently excluded, which can undermine the analysis and assessment that is required when undertaking an operation with fuzzy logic, an operation can be expressed as a probability rather than as a certainty. [57][58][59] [60] [61]

[62]reviewed strategy in searching for optimal dose combinations from three perspectives: (1) mainly experimental-based such as clinical trials on patients by the physician to determine the best dose combinations; [63] (2) Computational-guided experimental approach such as the combined use of humans aided by artificial intelligence in other to determine the best dose combination; [64] [65] and (3) mainly computational-based such as the use of artificial intelligence to gather data on the patients and come up with the best dose combinations, [66]based on the introduction of each strategy, a critical evaluation of their advantages and disadvantages should focus on the current applications and future improvements.

The decisions taken by medical experts in the diagnosis of a patient depend upon the experience, expertise, knowledge, capability, and perception of that medical expert. As the complexity of diagnosis increases, difficulties in diagnosis without any mistake becomes inevitable. Fuzzy logic presents compelling reasoning methods that can handle uncertainties and imprecision [67][68][69][70]An aggregation of medical experts' knowledge,

Malaria mostly tends to occur along the geographical margins of the malaria-endemic regions where there are favorable conditions to support the equilibrium between the human, parasite, and mosquito vector populations are disturbed., As reported by the Global technical strategy for malaria 2016–2030 Globally, an approximated value of around 241 million malaria cases was reported in 2020, among 85 endemic countries with malaria, which also include the territory of French Guiana, increased from around 227 million in 2019, mostly coming from countries in the WHO African Region.

(GTS) a baseline of 2015, there were 224 million estimated malaria cases [71]. Malaria is a primordial disease having an immense social, economic, and health burden and is mainly associated with tropical countries in Africa. Several studies have shown that malaria remains a significant public health problem in Africa [72]. However, concerted efforts are continually being made to control malaria spread and transmissions within and between communities [73] In work carried out by [74] [75] [76] [77]

A recent study concluded that malaria control programs that emphasized environmental management were highly effective in reducing morbidity and mortality [78] [79]. The research was conducted to establish the cost-effectiveness of selected malaria control interventions. It was concluded that in most areas in sub-Saharan Africa, coverage should be more vast, with highly effective combinational treatments should be the cornerstone of malaria control [80]. Therefore, there is pressing demand for using existing research approaches to the best deployment methods in malaria prevention, control, cure, and effective eradication [81].

Prescription Medication interaction (combinational therapy)

Types of Medication Interaction

Additive Effects

Based on a practice of more than thousands of years exploit, Combination therapies decreased toxicity, reduced development of drug resistance, and enhanced drugs efficacy due to these advantages; combinational therapy has become a routine standard for the treatment of multiple diseases [82] the addictive effect occurs with similar or slightly similar chemicals constituents, that complement each other properly when taken together

Synergistic Effects

Synergistic effects are when the sum effects are more than each chemical individually; in the field of medical research, the. Understanding the Classification of the concept of synergy can be complicated and thus categorized into two main categories based on their mode of action—pharmacodynamic(multiple agents act on the same biological targets, which result in enhanced therapeutic outcomes through their positive interactions) and pharmacokinetic synergy interactions between multiple agents during their pharmacokinetic processes (absorption, distribution, metabolism, and elimination) [83]

. This can create problematic situations because each chemical constituent is designed to work well independently.

Antagonistic Effects

Antagonistic effects are when the net effect of the chemical reaction is zero.

Antagonistic effects are essential because this is where we get antidotes for poisons.

A typical example of an antagonistic effect; so is the combination of caffeine and alcohol [84]

There is one more less-common type of interaction called potentiating effects. This is when one chemical enhances the effect of another chemical. Some chemicals are not toxic on their own, but when they are in the presence of some other chemicals, they become toxic.

Effects of Contraindications in Drugs and how they affect Patients

A contraindication is a situation in which a procedure, drug, or surgery should not be used due to its harmful nature to the person's health.

There are two types of contraindications:

- Relative contraindication means that caution should be used when two drugs or procedures are used together. (It is acceptable if the benefits outweigh the risk.)
- Absolute contraindication means that event or substance could cause a life-threatening situation. A procedure or medicine that falls under this category must be avoided.

Drug Interactions

The knowledge of drug interactions, especially on drug metabolism, absorption, elimination, and transport, may help inhibit adverse effects. Predicting pharmacodynamic interactions often demands a broader understanding of the operations of such effects. Increasing complexities of diseases with age often make it necessary to prescribe several drugs for one patient at a time. Consequently, an average 65-year-old patient is on five drugs simultaneously [85]. Prescription peaks in the 75 to 84 age group; a European study showed that approximately 34% to 68% of patients with a mean age of 81 years were taking six drugs or more [86]. Thus Interactions can lead to serious unwanted effects or a therapeutic reduction in the effects of some drug substances. Polypharmacy (drug combinations), common in elderly patients, increases the risk substantially.[87] [88],

A major consequence is that drug interactions can lead to serious adverse effects or reduce some compounds' therapeutic effects. Adverse drug effects are also sometimes avoidable problems during inpatient treatment. [89].

Impact of Chemical Concentration on Patients

Development of the use of fossil fuels for many purposes, humans have become exposed to a broader range of hydrocarbons and their by-products [90]. However, the number of pharmaceutical industries in the twentieth century has vastly increased human exposure to chemicals such as pesticides, herbicides, fungicides, and.

Excessive Concentration of Drugs in Patients

Paracetamol

Paracetamol concentrations impart diagnostic and prognostic information and define the need for therapy in overdose. [91] The prognostic importance of a serum paracetamol concentration in predicting hepatotoxicity is well established. For single ingestions of paracetamol, taken at a known time, an appropriately timed blood level (between 4 and 15 h) can be plotted on a nomogram which reliably predicts those patients at risk of hepatotoxicity. [92]

Paracetamol concentrations should be assessed in all patients who have ingested a potentially dangerous dose of paracetamol or if there is reasonable clinical suspicion that this has occurred [93].

Difficulties also arise when the time of ingestion is not known. In these circumstances, our practice is to attempt a worst-case analysis and treat on this basis and then repeat the paracetamol level at least two h after the previous collection.

Toxic alcohols

Alcohol-related intoxications, including ethylene glycol, methanol, diethylene glycol, and propylene glycol, can introduce a high anion gap, metabolic acidosis, and increased serum osmolality gap. The management of toxic alcohol ingestions is dictated by clinical signs, acid-base, and osmolarity measurements. Fomepizole or ethanol should be Administered to inhibit alcohol [94].

Acceptable Tolerability level of some drugs on the human body

Paracetamol

The tolerability of therapeutic doses of paracetamol (acetaminophen) is a significant factor in the wide use of the drug. The major challenge in the use of paracetamol is its hepatotoxicity after an overdose [95]. Prospective studies indicate that hepatotoxicity is higher in patients who ingest moderate to large amounts of alcohol. [96] Controlled clinical trials have found that the gastrointestinal tract very well tolerates paracetamol [97].

Literature of Prescription Management System

pharmacy management's essential responsibility is to supervise and manage the pharmacy employees to ensure healthy working relationships and outcomes. These functions are critical to the pharmacy's operation and should be explained by the management. 98]99]100]

101] electronic technology has been implemented to automate traditional systems. So, different copies of management systems in different scopes were presented. These systems include the services provided to companies as well as people, such as healthcare

[102]Procurement and distribution tracking systems of drugs are set of programs that obtain the supplies of drugs, distribute the drugs and monitor the inventory control of the drugs in the computer system. Using the pharmaceutical department of Port Harcourt University teaching hospital as a case study, the department uses the manual method to operate and lacks a sound drug information storage system. The method of tracking expired drugs is poor, and the recording system tends to be complex.

Improving Service Quality

In recent years, fuzzy-based data management systems and service quality evaluation and management systems are gradually becoming popular and more widely adopted in hospitals and medical clinics [103].

This growth can be attributed to the fact that fuzzy methods to effectively compute variables such as patient satisfaction, hospital environment, food quality, security, or medical staff. Fuzzy SERVQUAL is a popular tool used by managers to study the performance of their teams and explore possibilities in capacity building by minimizing redundancy or gaps in service quality [104].

3. Materials and Methods

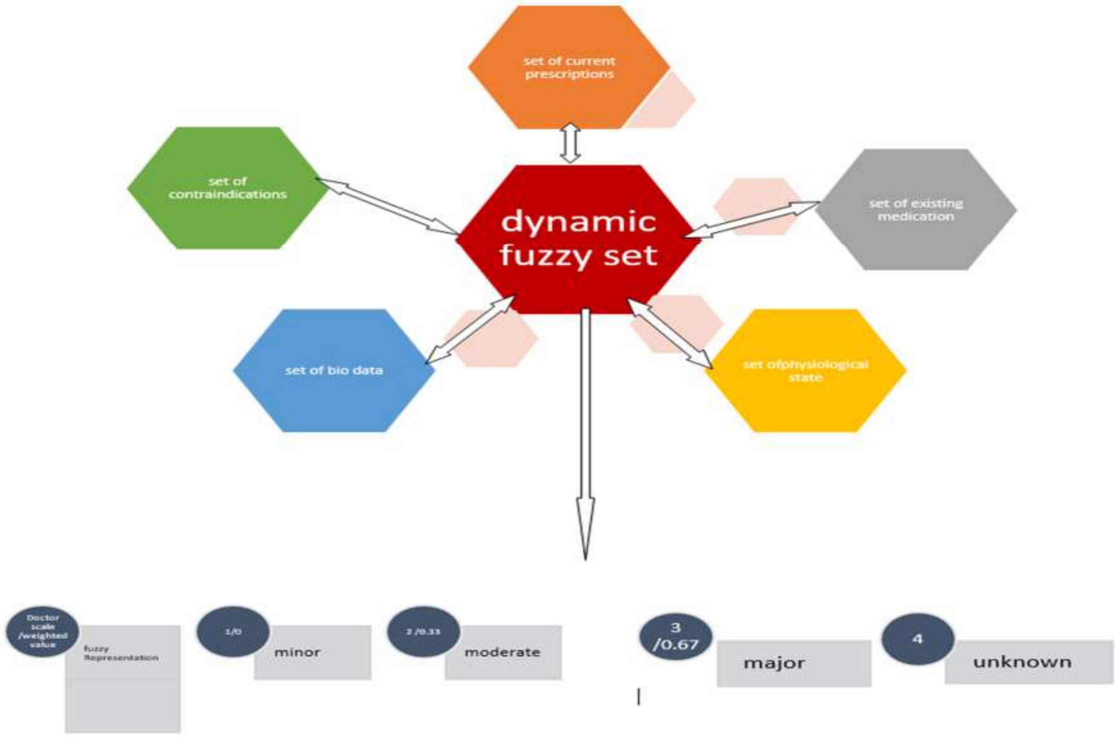
This Section presents a proposed system development strategy;

the proposed system modeling approach

To accomplish the proposed system 1. a mathematical programming approach was used. The model has the following sets representing each of the factors and others required to accomplish a functional design:

i. A set of all possible drugs that can be used to treat specific illnesses, their chemical constituent, and their dosage quantity (ml)
ii. It also contains a set of existing prescriptions, if any exist for the patient before
iii. It contains a set of physiological state
iv. Set of patient allergy and contraindications
v. Set of bio-data

Fig 3. Below depicts the set of these critical factors. (set of current prescriptions, set of contraindication, set of biodata, set of physiological state, set of an existing medication, and an evaluation of the dynamic fuzzy set in the course of the dynamic interaction; all possible prescriptions will carry weight, and based on the appropriate weight best suited to the patient's conditions; this will aid the practitioner in making appropriate prescriptions suitable for the patient.



<u>weighted values and their fuzzy representations</u>

Fig 3 shows the dynamic fuzzy interactions and their weigthed values

Data/ Information gathering

The data and information gathering approaches adopted in this study are discussed next

Personal Interview Method

Several meetings were arranged with some doctors and pharmacists from different pharmaceutical companies and medical clinics; interviews were carried out. They were able to clarify how physiological conditions, medical conditions, and patient features can affect the kind of prescriptions prescribed for them. Each of their reports was collected and vetted to give a viable operating dataset. Some of the vital information during the interview processes are:

i. Several factors need to be considered while prescribing the drug. Understanding how the drug is previously taken could affect the kind of prescription that will be administered.

ii. Biodata (weight temperature pressure etc.) is a significant factor to be considered

iii. Many times, food intake by the patient can also affect the prescription. E.g., Taking alcohol after taking drugs can result in food-drug interaction. Drug prescribed is evidently for nutrient provision. As such, some foods and beverages can affect the body's ability to absorb nutrients. The habits of smoking and drinking can have an adverse effect on Medications. Alcoholic consumption while on the antibiotic metronidazole causes skin flushing, nausea, headache, and palpitations. Alcohol enhances the hypoglycemic effect of anti-diabetic medication and the hypotensive effect of many blood pressure drugs. Avoiding alcohol while on medications is best.

iv. It is noteworthy to consider how Drugs can accelerate the existing disease in a body and how disease can counter the positive effect of drugs—for example, Disease conditions like Asthma. Asthmatic patients should be careful when using drugs like ibuprofen as they may cause airway constriction.

v. It is imperative to identify the critical difference between Physiological Conditions and disease conditions. For example, pregnancy is a physiological condition, whereas Asthma, Diabetes is disease conditions.

The data was collected using the secondary data collection method, which involves a direct interview of consultants in general medicine. The data collected include various methods for diagnosing some ailments. Moreover, various pharmaceutical drug constituents can be used to treat such ailments effectively. In addition, previous research works and texts in the subject area were consulted, which were used to understand the proposed system requirements specification.

The following series of the table generated in the course of information gathering (source from field study) forms the database of the proposed system

Table 3.2 Information on Prescription drugs, their content, and contraindication

Drug	Rx ID	Type	Constituent	Interaction	Medical. Personel Representation

Basafen Syrup	6154000284367	Syrup	Microcrystalline Cellulose, Colloidal Anhydrous Silica, Maize Starch, Purified Talc, Calcium Stearate, White-Base Granules, Sodium Starch Glycolate, Hydroxy Propyl, Methyl Cellulose, Lactose BP Polyethylene Glycol, Titanium Dioxide, Erythrosine Lake IH Iso Propyl Alcohol	Captopril, lisinopril, angiotensin, valsartan, losartan, cidofovir, prednisone, lithium, "water pills," furosemide).	1
Biogil		Tablet	Metronidazole, Norfloxacin	Metoprolol, atenolol, guanethidine, halothane, methyldopa, rolapitant, tricyclic, amitriptyline, desipramine.	2
Bioraj Ciprofloxacin		Tablet	poly (ethyl acrylate methyl methacrylate)-dispersion 30%, magnesium stearate, methyl-hydroxypropyl cellulose, polysorbate 20, polyvidone 25; *diluent:* strawberry flavor 52312, strawberry flavor 54267, lecithin, medium-chain triglycerides, sucrose micronized, and purified water.	Theophylline	2
Bioramol Tablet		Tablet	Acetaminphen	warfarin and coumarins, metoclopramide, domperidone,	3
Biofenac Caplet		Tablet	D. Diclofenac and Paracetamol	aspirin: increases the undesired harmful effects warfarin: increases the risk of stomach and intestinal bleeding methotrexate: Biofenac restricts the accumulation of methotrexate in kidneys, which may lead to harmful effects of methotrexate	2
Biocipro Cap		Tablet	Ciprofloxacin HCL	Flibanserin	1
Biolin		Syrup	Methanol, NH4CL, Sodium Citrate	Alcohol, Alginic acid, Aluminum hydroxide, Anisindione, Apomorphine,	2

				Aspirin, Calcium carbonate, Dicumarol, Maprotiline, Methadone	
Kisivite Drop		Syrup	Vitamin B12, C, A, nicotinamide		2
Bioracee Tablet		Tablet	Ascorbic Acid	amphetamine, used in the treatment of excessive sleepiness,sleep paralysis or obesity and patients affected by urine acidification. Bioracee may acidify the urine and reduce the blood levels of amphetamine by improving kidney excretion. In case of reduced amphetamine efficiency, discontinue the use of Bioracee. Also, acidification of urine by Bioracee will change the excretion of some drugs affected by the urine pH when used in combination. Standard monitoring of treatment is warranted.	2
Biotonic Capsule		Tablet	Folic Acid, Ferric Ammonium Citrate (FAC), vitamin B2, Cyanocobalamin	Alcohol Barbiturates Chloramphenicol Cholestyramine Colchicine Diphenylhydantoin Epoetin Glucose Methotrexate Neomycin	3
Biobucap		Tablet	Iburopen, Paracetamol and Caffeine	ketoconazole, levoketoconazole.	2
Biomag Suspension		Tablet	potassium chloride, sodium chloride, sodium hydrogen carbonate, macrogol	Abacavir, Aspirin Barbiturates, Dolutegravir, Lamivudine, Lithium, Memantine, Paricalcitol, Prednisone, Quinidine	2

Ulcamed		Tablet	bismuth oxide, corn starch, povidone K30, polyacrylic potassium, macrogol 6000, and magnesium stearate (E470b) in the tablet core and polyvinyl alcohol, macrogol 4000, talc, and titanium dioxide (E171) in the film coat.	Alcohol Antacids	1
Paracetamol	161	Tablet	Maize starch, Potassium sorbate, Purified talc, Stearic acid, Povidone, Soluble starch	Teriflunomide Pexidartinib Ethanol Leflunomide Levoketoconazole Lomitapide Mipomersen	1
Coartem			20 mg artemether, 120 mg lumefantrine, colloidal silicon dioxide, croscarmellose sodium, hypromellose, magnesium stearate, microcrystalline cellulose, and polysorbate 80	antiviral medicine to treat HIV or AIDS; cancer medicine; an antidepressant; antibiotics; antifungal medicine, or medicine to treat tuberculosis; seizure medication	1

Table 3.2 above shows information obtained from prescription medications, their content, and contra-indication

Table 3.3 shows physiological state and contraindications

Physiological State	ContraIndication
Pregnancy	Chloramphenicol. Cipro and levofloxacin. Primaquine. Sulfonamides. Trimethoprim (Primsol) Codeine. Ibuprofen (Advil, Motrin) Warfarin (Coumadin) Clonazepam Lorazepam

Table 3.3: above shows the set of drugs that a pregnant person should avoid; both primary and secondary sources have proved to them that any of the drugs above or any drug that has them

as content should be avoided as they have **Severe** medical side effects on the pregnancy and the baby.

Table 3.4 showing Drug, Drug Content, and contraindication

Drug	Content	Contra-Indication
Paracetamol	100mg Maize starch, Potassium sorbate, Purified talc, Stearic acid, Povidone, Soluble starch	Teriflunomide Pexidartinib Ethanol Leflunomide Levoketoconazole Lomitapide mipomersen
Ibuprofen	Lactose, Maize Starch, Hypromellose, Sodium Starch Glycollate, Colloidal Anhydrous Silica, Magnesium Stearate, Sucrose, Talc, Titanium Dioxide (E171), and Carnauba Wax.	Aspirin, NSAIDs
Aspirin	Aspirin (324 Mg) (Nsaid). Inactive Ingredients: Carnauba Wax (May Contain This Ingredient), Corn Starch, Hypromellose, Powdered Cellulose, Triacetin.	Ibuprofen, NSAIDs
Tylenol	Acetaminophen 325 mg. Magnesium stearate, modified starch, powdered cellulose, pregelatinized starch, sodium starch glycolate.	carbamazepine, isoniazid, rifampin, alcohol, cholestyramine, warfarin
Famotidine	Famotidine, hydroxypropyl cellulose, hypromellose, iron oxides, magnesium stearate, microcrystalline cellulose, corn starch, talc, titanium dioxide, and carnauba wax.	atazanavir, dasatinib, delavirdine, itraconazole, ketoconazole, levoketoconazole, pazopanib, cimetidine, nizatidine, ranitidine, any drug that has famotidine, NSAIDs

Table 3.4 above shows the Sample of different types of pain relief medication, their content, and contraindications

Table 3.5 sample table for disease and contraindication

Disease	**Contraindication**
Diabetes	Azole antifungals. Rifampin, isoniazid. calcium channel blockers, beta-blockers, thiazide diuretics. Corticosteroids. Estrogen. Nicotinic acid. Oral contraceptives. Phenothiazines. NSAIDs

Asthma	Aspirin. NSAIDs, Ibuprofen, Motrin, Advil, Naproxen, Beta Blockers

Table 3.5 above shows a sample of disease conditions and their contraindications.

Note that biodata and existing prescriptions are to be generated or retrieved from information sources databases or provided by the patient and the attendant responsible for biodata assessment

Sample mapping of patients' conditions and prescriptions (illustrating how the system interacts)

Mathematical interpretation

A fuzzy set A in a universe U is a mapping

$A\colon \longrightarrow [0,1]$:

$u \mapsto A(u), \forall u \in U$

A fuzzy set A in U is said to be contained in a fuzzy set B in U; the union and the intersection of two fuzzy sets A and B in U is given by,

$A \cup B(u) = max(A(u), B(u))$

$A \cap B(u) = min(A(u), B(u))$

The membership function assumes values in the interval [0, 1]. The range between 0 and 1 is referred to as the degree of membership. The Membership function µA (x) is defined as an element in the universe U having a crisp value of 1 or 0. For every $x \in$ U

$$\mu_A(x) = \begin{cases} 1 \text{ if } x \in A \\ 0 \text{ if } x \notin A \end{cases}$$

Finding Theoretical Point of Intersection

Consider patient T, managing diabetes (Q) and also having a physiological condition of Pregnancy (J), in need of a pain prescription of ibuprofen due to its effectiveness. The breakdown of the automated prescription is as follows:

The existing prescription the patient is on for diabetes is considered as Q and stored in the database to be utilized later

Mathematically,

P = (A ∩ B).

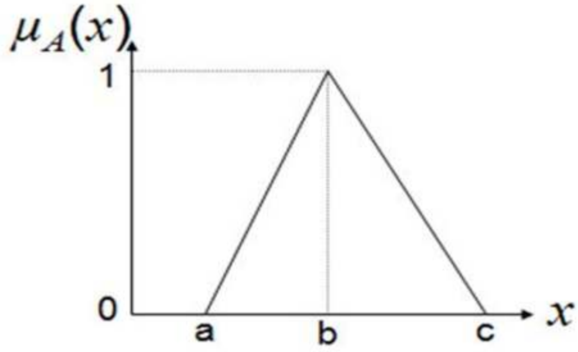
This forms a new set to be considered.

To handle the new medical issue reported, Pain Prescription, Consider set B having lists of drugs and their content, as well previous prescriptions in use, which famotidine as a new set.

i. I am plotting the Existing Medication (J), such as metformin, a diabetics medication, against the drugs set (set B). Several drugs could be prescribed in the drugs set, such as famotidine, Tylenol, and acetaminophen for pain, and since those drugs do not interfere with the diabetes medication K = J(P ∩ set C).

Patient T ={Q∩(k(A ∩ B)∩C}.

Using the equation below to determine the Range degree of severity This is achieved by using a triangular fuzzifier to obtain the fuzzy triangular numbers



$$\mu_C(k_i) = \begin{cases} 1 & \text{if } k_i < a \\ \frac{k_i-a}{b-a} & \text{if } a \le k_i < b \\ \frac{c-k_i}{c-b} & \text{if } b \le k_i < c \\ 0 & \text{if } c < k_i \end{cases}$$

$$\text{K}_{mild}(x) = \begin{cases} 0 & \text{if} \quad x \le 1 \\ \dfrac{x-0.2}{0.2} & \text{if} \quad 0.1 \le x \le 0.3 \\ \dfrac{0.2-2}{0.2} & \text{if} \quad 0.2 \le x \le 0.3 \\ 0 & \text{if } x \ge 0.2 \end{cases}$$

$$K_{\text{bad}}(x) = \begin{cases} 0 & \text{if} \quad x \le 0.3 \\ \dfrac{x-0.45}{0.15} & \text{if} \quad 0.3 \le x \le 0.6 \\ \dfrac{0.45-x}{0.5} & \text{if} \quad 0.45 \le x \le 0.6 \\ 0 & \text{if} \quad x \ge 0.5 \\ & if\ x \ge 0.5 \end{cases}$$

$$K_{\text{severe}}(x) = \begin{cases} 0 \;\; \dfrac{x - 0.75}{0.15} & \text{if} \quad x \;\; 0.6 \leq 0.9 \\ \dfrac{0.75 - x}{0.15} & \text{if} \quad x \; 0.75 \leq x \leq 0.9 \\ 0 & \text{if} \quad x \geq 0.8 \end{cases}$$

This is achieved by using a triangular fuzzifier to obtain the fuzzy triangular numbers

Fuzzy values = Linguistic variables

[0.1 – 0.3=[mild,]

[0.3 - 0.6 =[moderate,]

[0.6 - 0.9 = [Severe,]

The medical personnel was asked to assign severity values (Sv) to describe the severity of the interactions between the drugs: between 1-3, *Sv* = 1 (mild), 2= (bad), and 3 (severe/ very bad). The system will compute the degree of severity from the values to determine the severity weight of the medication interaction; this is obtained using the triangular fuzzifier to obtain the fuzzy triangular numbers is denoted as

$$X^* = \frac{\sum_{i=1}^{n} \bar{xp}}{n}$$

mild = (1–1)/3 = 0/3 = 0

moderate = (2–1)/3 = 1/3 = 0.33

Severe = (3–1)/3 = 2/3 = 0.67.

Table 3.6 shows an example of the aggregate fuzzy values of some drug interactions

	Current medication	Existing medication	Physiological state	Biodata	Disease condition	Drug Contraindications	Total agg/n	Suggested Drug
Patient 1								
First medication	Ibuprofen	metformin	pregnancy	F, 35, 119kg	diabetes			
		0	0.67	0	0	0	0.13	
Next medication								
	Chloroquin	ibuprofen	pregnancy	F, 35, 119kg	Malaria			
		0.67	0.67	0	0		0.80	Chloramphenicol

Next medication						—		
	Chloramphenicol	aspirine	-	F, 35, 119kg	malaria			
		0,67	0	0		0	0.13	
Patient 2								
	Aspirine	ibuprofen	-	M,30 180kg	asthma			
Patient 3		0.67		0	0.67	0	0.80	Tylenol
	Mefloquine	seizure medication		M,30 180kg	HIV			
		0.67	0		0.67	0	0.80	Coartem

The table above (table 3.6) shows an illustration of how the critical factors interact with its dynamic fuzzy system, which flags off potentially harmful medication combinations and can also suggest a less harmful alternative

The Root Sum Square (RSS) was applied to combine the effects of the interactions of the critical factors to obtain a meaningful inference. The root-sum-square represents an inferential method used in the design to help combine the effects of all applicable rules The method is to integrate the effects of all rules that are of outmost significance in the proposed model.

Root Sum Square = $\sum_{x=1}^{n} R_x^2$

$$\sqrt{R_1^2 + R_2^2 + R_3^2 + R_4^2 + R_5^2}$$

RSS to calculate the severity of the interaction of prescription for first medication for patient one =$\sqrt{0^2 + 0.67^2 + 0^2 + 0^2 + 0^2}$ =0.4

RSS to calculate the severity of the interaction of prescription for second medication for patient one = $\sqrt{0^2 + 0.67^2 + 0.67^2 + 0^2 + 0^2}$ =0.89

RSS to calculate the severity of the interaction of prescription for second medication for patient one=$\sqrt{067^{.2} + 0^2 + 0^2 + 0^2 + 0.67^2}$=0.89

The result of 0.4 obtained from the pregnant woman condition falls into the condition of mild, which implies that the prescription is relatively safe forbearing other conditions, whereas, for the asthma patient, the value of 0.89 falls into the scale of significant interaction, which implies possible dire consequences if the prescription is administered. The system considers all the previous prescriptions the patient is on and other critical factors highlighted; if the value of all the possible interactions is above 0.4, which is the minimum value set, the system will flag off the prescription and consequently advise the prescriber by then suggesting the best alternative among available drugs that can combat disease conditions with minimum interactions.

for the asthma patient, the value of 0.89 falls into the scale of severe interaction, which implies possible dire consequences if the prescription is administered, and the IF, THEN Conditional algorithm statement is used to flag off potential dangerous drug interactions and suggests a better medication alternative

Algorithm: Algorithm of the proposed system

1. Retrieve data from medical personnel's description of severity in the form of crisp input
2. Change the crisp value into a fuzzy value
3. Merge the results of each rule (Inference)
4. Convert the output to non-fuzzy values (Defuzzification)
5. Determine the best prescription based on the crisp input gotten from the defuzzification stage
6. Suggest a less severe prescription based on the defuzzification output based on the range of severity gotten from the fuzzifier

proposed system design methodology

having gathered all the requisite requirements for the proposed system, structured system analysis and design methodology was adopted for the proposed system design. A bottom-up refinement system development concept was adopted in this study. Control flow diagrams were used to represent the proposed system control flow; fig .4, the proposed model depicted by a context diagram is depicted in fig 5

Control Flow Diagram

A control-flow diagram (CFD) is used to describe the control flow of a business process, process, or review[105].

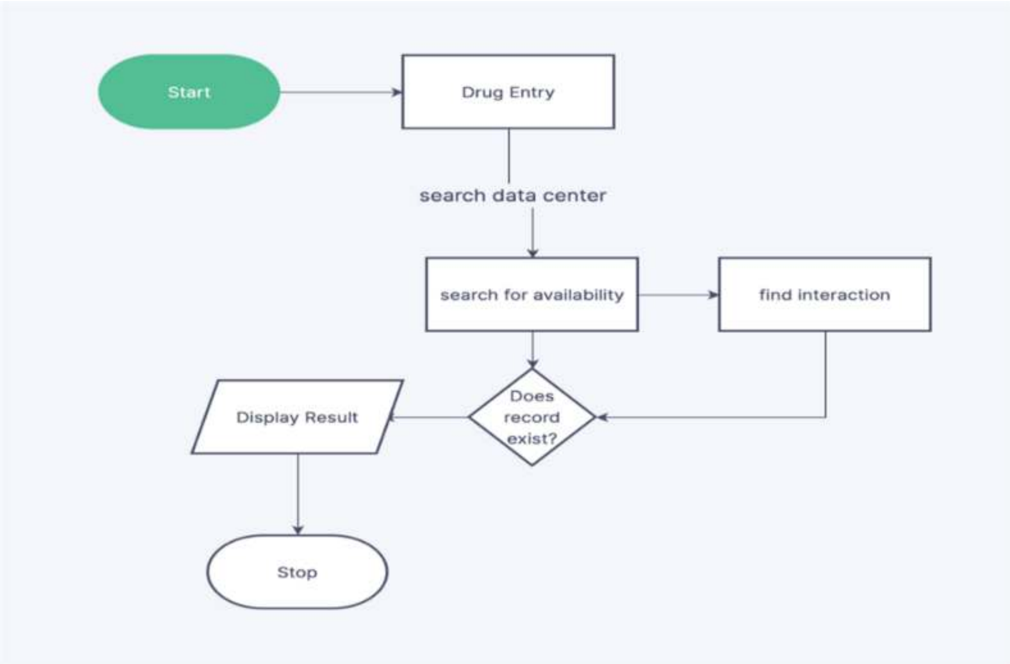


Figure 4: Control Flow Diagram

Context Diagram

A system context diagram in software engineering is used to interpret the relationship between the system, part of a system, and its interactive environment [106].

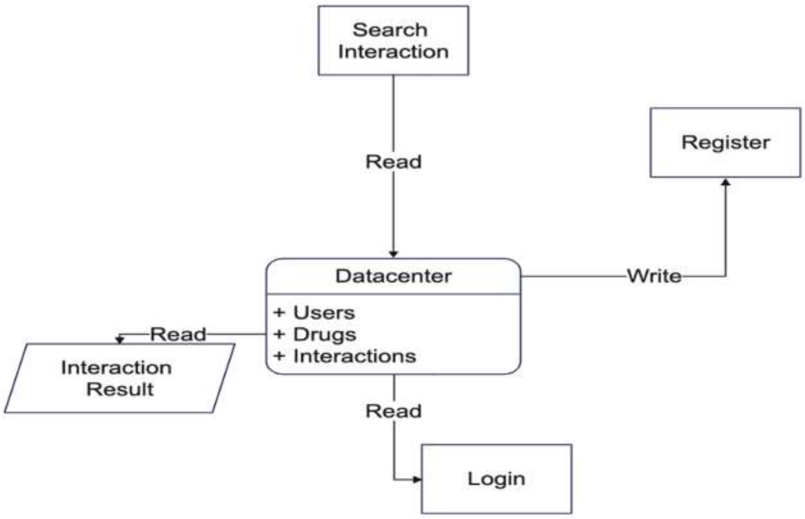


Figure 5: proposed Context Diagram

Proposed system implementation

Proposed system development tools

the three primary system development tools were used to implement this system. These are JavaScript, node JavaScript, and Postgres database management system

JavaScript

JavaScript was extensively used in the development of this system. It was used to develop the proposed system business logic; the reason for this choice was informed by its features of platform neutrality, that is, it could be used across different hardware, software, and virtual machine ware (VM ware). In addition. It runs on a network (internet)seamlessly. Again it was easy to learn, and the researchers were more proficient in the use of this language compared to others. Very importantly, the proposed system has the capability to retrieve all the requisite information dynamically from remote databases in the course of making prescriptions. That is, all the required factors for a patient can be gathered from different data sources since patients are likely to use various clinics in different geographical locations. As long as access is granted, the system can retrieve all needed information from these remote data sources.

Node js

Javascript was augmented with node javascript

The integration of node javascript into the business logic implementation was informed by the need to be able to dynamically query databases implemented in diverse database design systems running on different software platforms(operating systems)and also systems running on different hardware platforms

Postgresql

Postgres was used in the proposed system database management system. The proposed system was data-intensive, and therefore, a robust, reliable, and efficient database management system was required. Data retrieved from different databases designed with various applications can be readily accommodated by the Postgres database system with minimal alterations.

Proposed System Testing

After the system had been developed and a series of debugging was conducted to achieve the desired result, and extensive testing of the system was then done. A detailed description of these testing results is discussed with sample screenshots showing the running application at various stages of operation

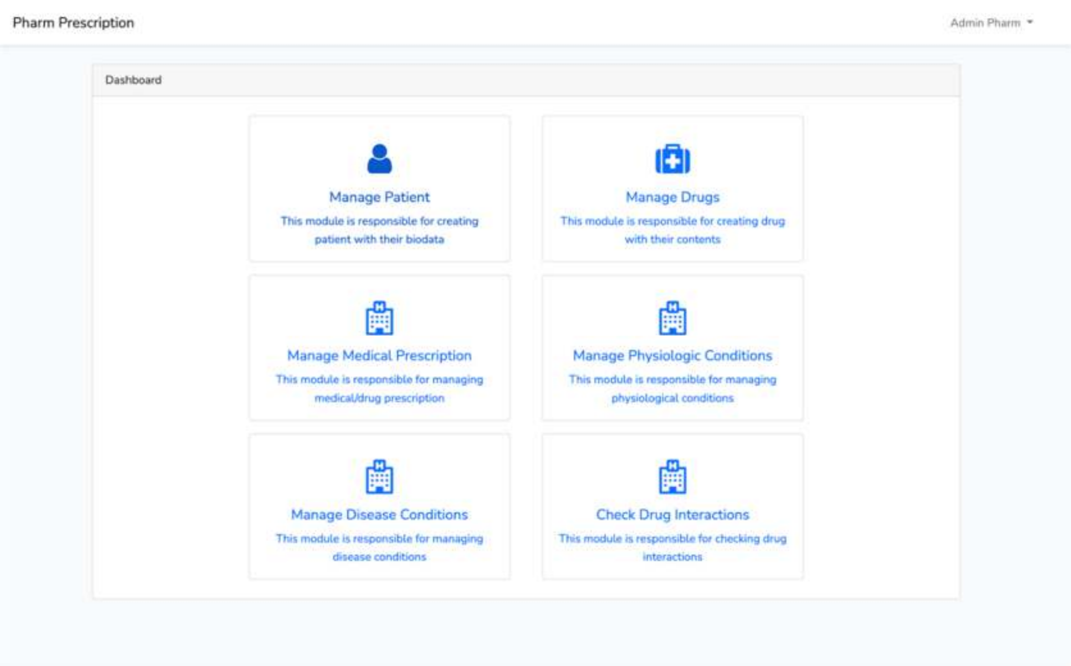


Figure 6: Home Page of the proposed system

The figure above shows the Sample main page after login showing modules to manage patients, manage drugs, manage medical prescriptions, manage physiological conditions, manage disease conditions and check drug interaction modules.

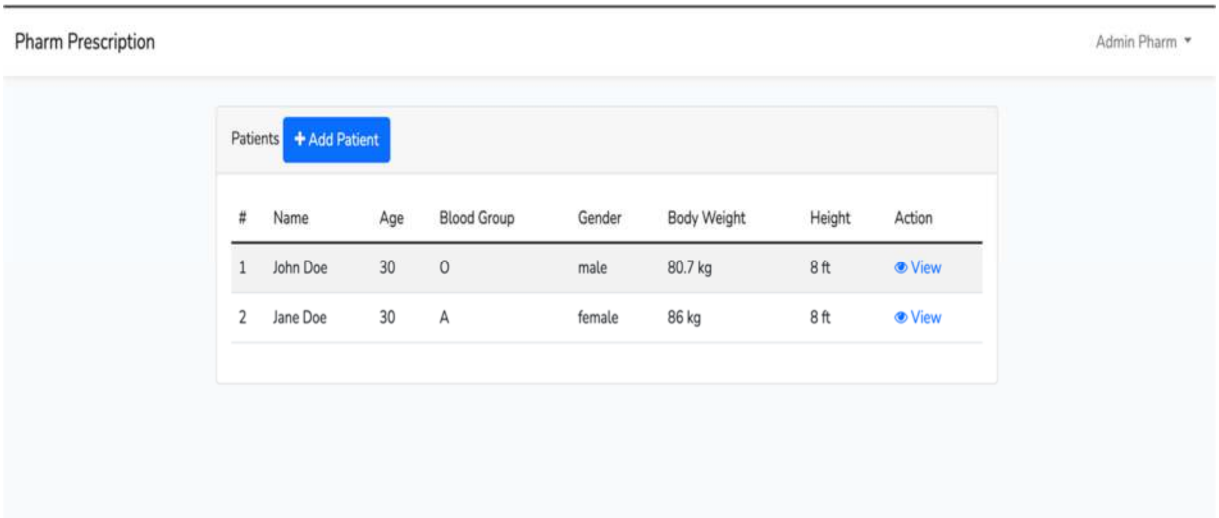


Figure 7: Sample Patient Details page

This interface shows the record collected about a patient, such as biodata(first name, last name), blood group, gender, body weight, and height.

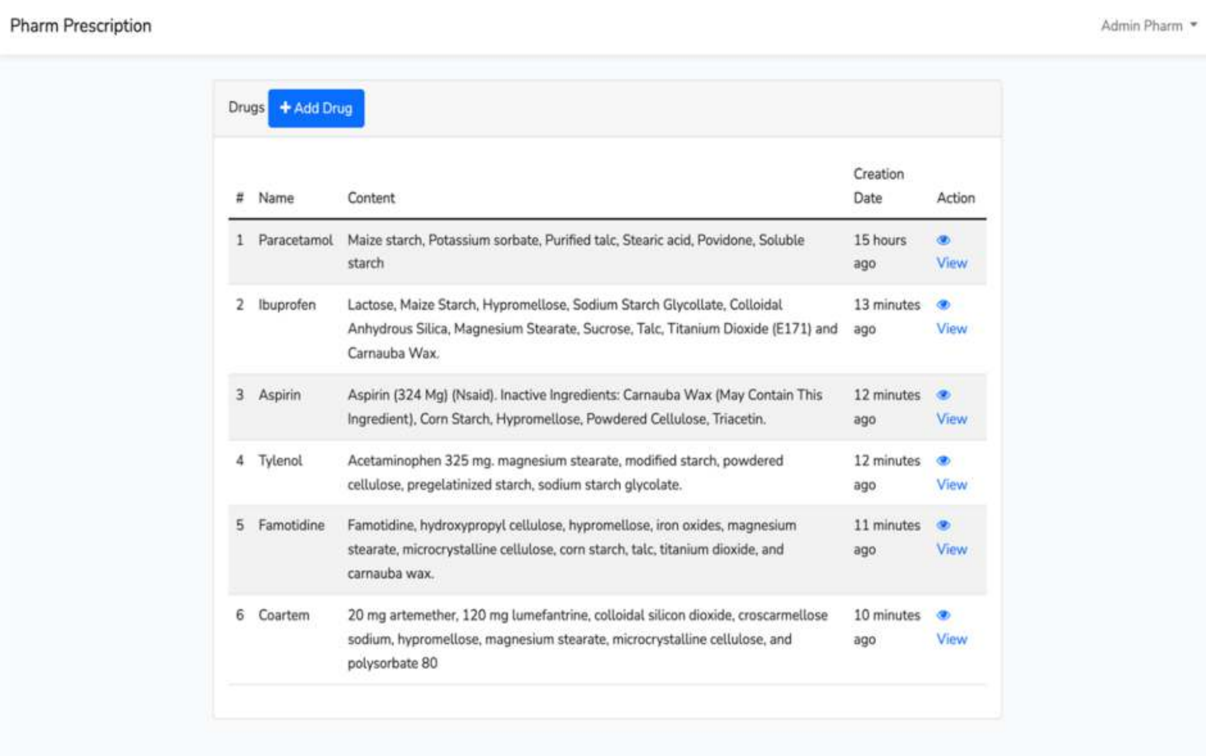


Figure 8: above shows a sample list of the available drugs Database and their contents.

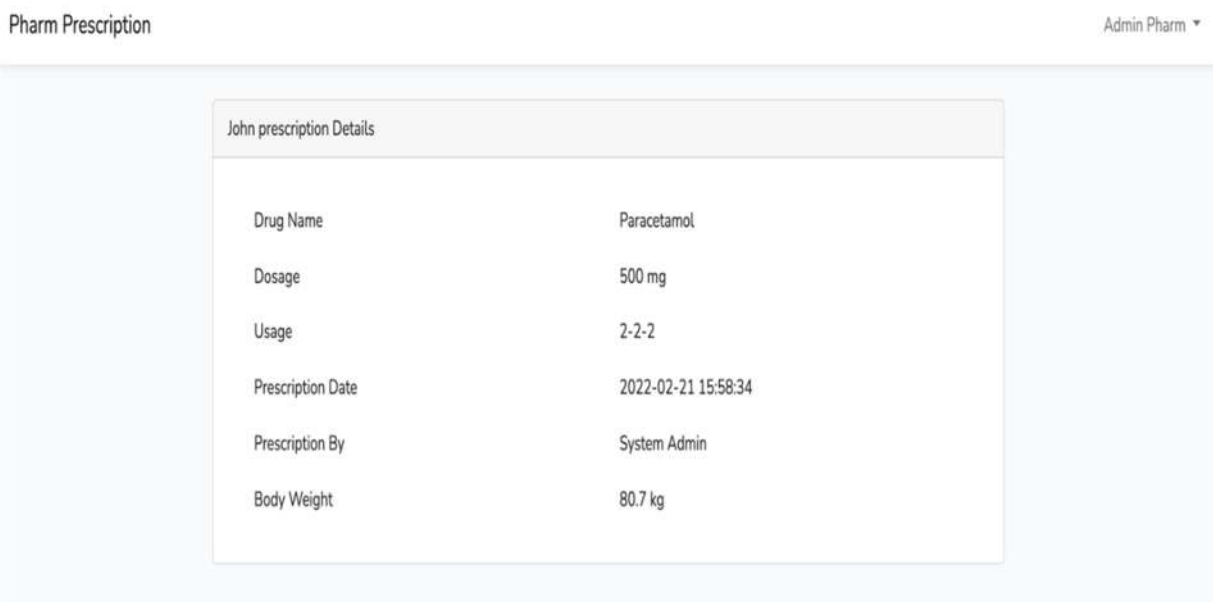


Figure 9: above shows sample prescription details and current body weight, dosage, and usage at the time of prescription for a sample patient.

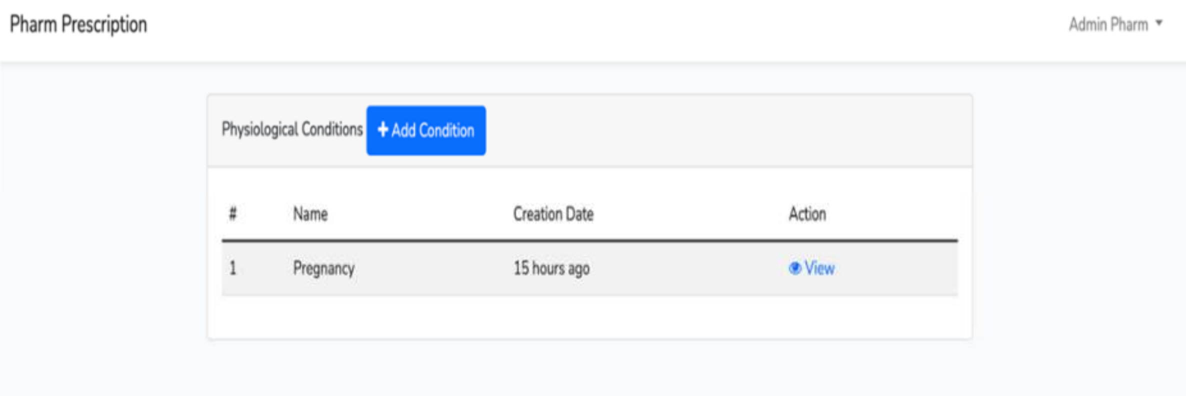


Figure 10 shows the interface of available physiological conditions.

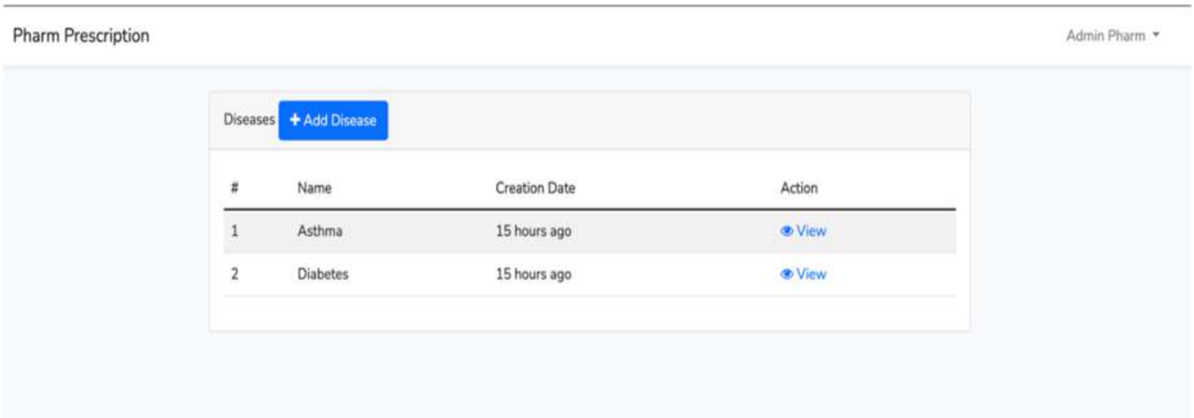


Figure 11 above Shows available disease conditions.

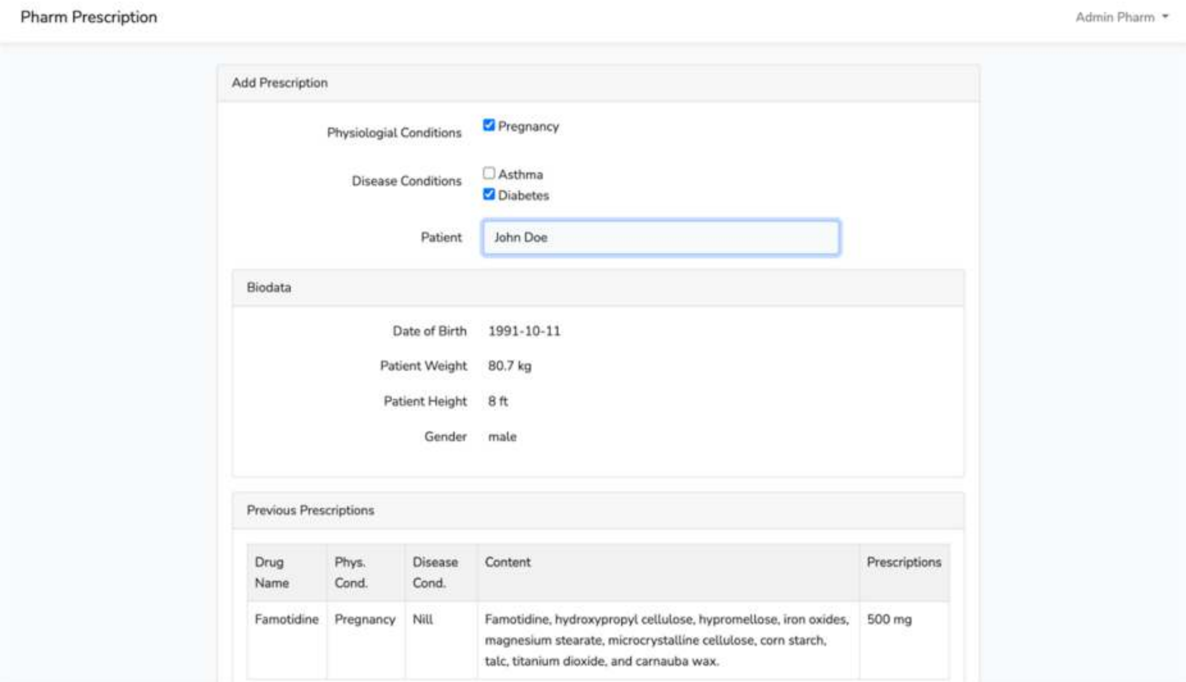


Figure 12: shows existing physiological conditions as well as previous prescriptions

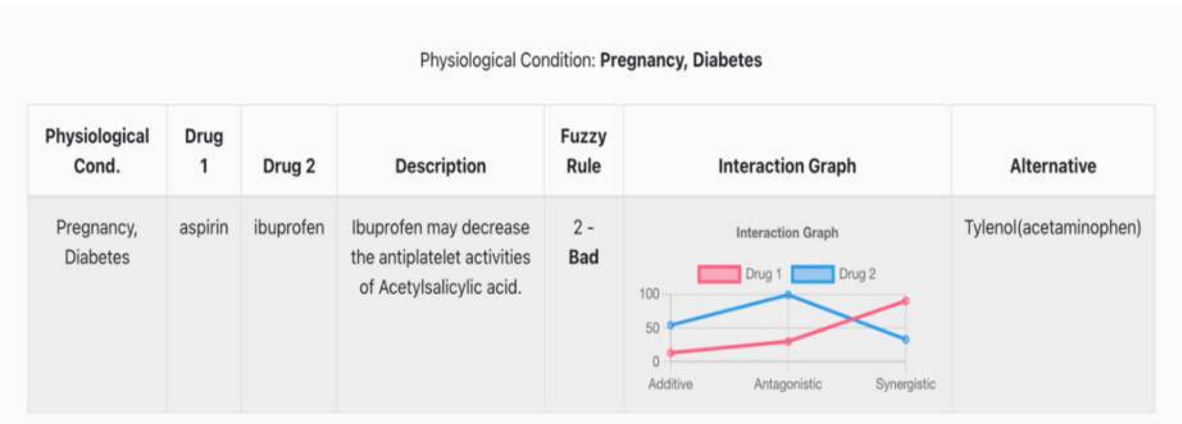


Figure 13 above: sample page showing the interaction between 2 suggested drugs (aspirin and ibuprofen) in the course of trying to get a suitable prescription for a patient base on the consideration of all possible Critical factors affecting the designated patient. A scenario of a pregnant woman with some conditions was used to illustrate how the system functions in this testing; for example, if a pregnant woman is on diabetes medication and also experiencing pain having taking pain medication (aspirin), but needs a more powerful pain relief medication based on the previous medication combining the two drugs, aspirin, and ibuprofen, has a high degree of adverse effects. Tylenol, also known as acetaminophen, should be used instead.

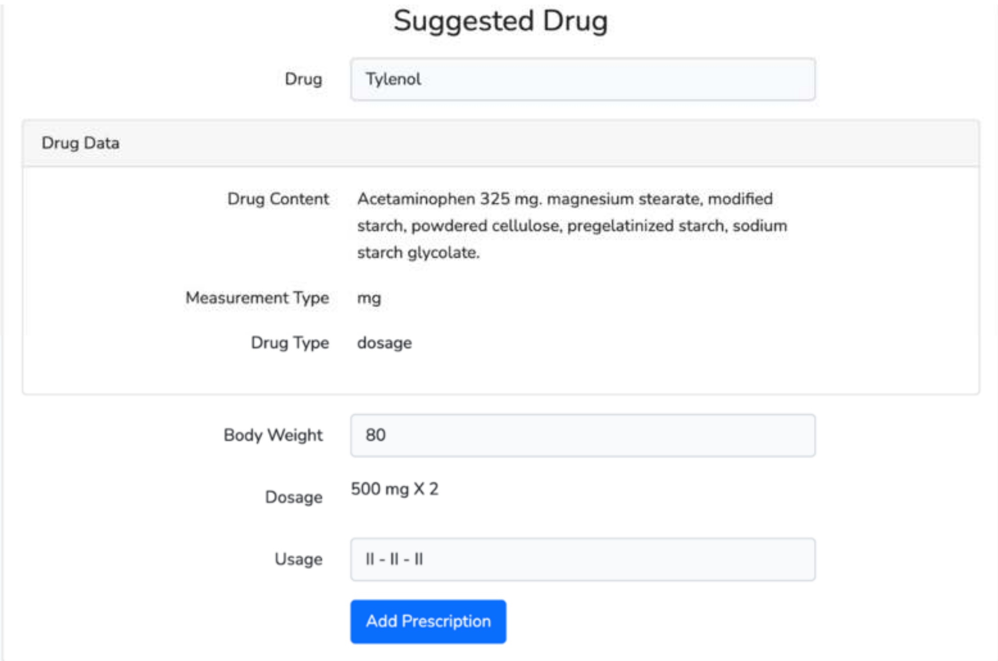


Fig 14 below shows the safe prescription that replaces the previous two drugs. This interface shows suggested drug details, dosage, usage, as well as body weight during the time of prescription. This is because body weight can change during the prescription process. This is considered during the prescription process.

Conclusion and Future works

Errors and faults in medical prescriptions are, in most cases, preventable. The ultimate purpose of healthcare is to ensure that the best possible care is given to the patients. To this end, the need for a system to manage critical pharmaceutical prescriptions cannot be over-emphasized. In this study, a review of subsisting electronic prescription systems was reviewed. Based on the knowledge gained, a more encompassing prescription system that considers the multiplicity of critical factors in the course of pharmaceutical prescriptions was developed. The test runs conducted using this developed system showed that better care from the perspective of pharmaceutical prescriptions could be readily archived from the traditional approach to prescription handling and created a model to manage critical pharmaceutical prescriptions. Further studies to include a broader range of data on drug contraindications and the Inclusion of an adaptive neuro-fuzzy inference system

The Corresponding Author, LAWANSON OLUBODE FRANCIS, states that there is no conflict of interest/Competing interest on behalf of all authors AWEH OPANI M. (Ph.D.), BELLO ALABI O. (Ph.D.).

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