
Full Research Paper

# Development of Anti-Polypharmacy Management System

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## ABSTRACT

The prevalence of adverse drug reactions, adverse drug effects, avoidable deaths, and other drug-related problems arising from multiple drug administration is a wake-up call to our medical practitioners and the world at large, hence prompt action is required to this effect. In this paper, a computerized web-based system called “Anti-Polypharmacy Module” (APM) is being proposed which is geared towards checking the menace of polypharmacy by highlighting its adverse effect and drug-drug interactions. The drug library which contains most of the required information will be used to accomplish this task. The application is designed to be a user-friendly one. The system methodology for this work is the System Development Life Cycle (SDLC). This system is implemented using Java-servlet (JSP), JQuery, and SQL as a collection of software development tools. It is also a web-based application hence HTML5 and CSS3 are carefully crafted together for maximum user-friendliness. Apache Maven and Tomcat 7 are deployed for the back-end server technology. For database query optimization, the basic rules are strictly followed as discussed in the methodology.

Keywords: Polypharmacy, Paediatrician, Therapeutic, Morbidity, Mortality, Drug-bank Database

**Proceedings Reference Format**
Aimufua, G.I.O. Onyechi, N.P. & Muhammad, U.A. (2021): Development of Anti-Polypharmacy Management System. Proceedings of the 28th iSTEAMS Intertertiary Multidisciplinary Conference. American International University West Africa, The Gambia. October, 2021. Pp 175-184 www.isteams.net/gambia2021.
DOI - https://doi.org/ 10.22624/AIMS/iSTEAMS-2021/V28P14


## 1. INTRODUCTION

Polypharmacy refers to the use of a large number of medications, commonly considered to be the use of five or more. Polypharmacy is a consequence of having several underlying medical conditions and it is much more common in elderly patients. Robert, Joseph, & Emily, (2013) opines that an estimated 30 to 40 percent of elderly patients take five or more medications daily. Clinical consequences of polypharmacy in the elderly published by HHS Public Access opined that an estimated 30 to 40 percent of elderly patients take five or more medications daily. Among these users, the average number of medications is six per user. Forty-seven percent used five or more medications, 13 percent used 10 or more, and 3 percent used 15 or more. This implies that using one or more of these medications may be questioned or unnecessary. Hence, polypharmacy also can be defined as the use of more medications than are clinically indicated.

As stated above, the major reason for polypharmacy is that a patient has many co-existing medical conditions for which he is being treated. In addition, when an individual presents cases such as heart failure, diabetes, and high blood pressure, combinations of two to three different medications are recommended. If medications for symptomatic relief are added, it is easy to see why patients end up with a large number of medications. In most cases a new medication is prescribed to treat the adverse effects of another drug, oftentimes stopping or changing the dose of the offending drug would solve the problem. Another contributing factor is that patients see different physicians for their medical conditions, and being under the care of several specialists is a major reason for polypharmacy. This is so because specialists often focus on their area of expertise rather than on the patient as a whole.

There is often a need for a primary care physician a general internist, a family practitioner, or a pediatrician to coordinate the use of multiple medications. Another reason for polypharmacy is that the documentation of why a medication was prescribed initially is often missing in the medical record, making decisions to consider termination of treatment difficult to make later. As a result of this, there is a tendency for doctors to let patients continue the medications they are taking, especially if the indications are unclear or unknown. In addition to medications lacking an indication, other medications may be of limited value or are therapeutic duplications.

The definition of an ADR is often confused with that of an adverse drug effect (ADE). The World Health Organization (WHO) defines an ADE as “any untoward medical occurrence that may present during treatment with a pharmaceutical product but which does not necessarily have a causal relationship with this treatment” (WHO 2005). The WHO defines an ADR as “a response to a drug which is noxious and unintended and which occurs at doses normally used in man for prophylaxis, diagnosis, or therapy of disease or the modification of physiologic function.” An ADR is a type of ADE whose cause can be directly attributed to a drug and its physiologic properties. The main distinction between ADRs and ADEs is that ADRs occur despite appropriate prescribing and dosing, whereas ADEs may also be associated with inappropriate use of the drug or other confounders that occur during drug therapy but are not necessarily caused by the pharmacology of the drug itself.

Adverse drug reactions occur almost daily in health care institutions and can adversely affect a patient's quality of life, often causing considerable morbidity and mortality. Adverse drug reactions may cause patients to lose confidence in or have negative emotions toward their physicians and seek self-treatment options, which may consequently precipitate additional ADRs. This risk of adverse drug effects increases based on the number of medications prescribed and taken.

These adverse drug effects often require physician contacts and, in some cases, emergency room visits or hospitalizations. However, if an adverse effect emerges, it can be very difficult to figure out which of the many drugs is the cause. Another possible problem is what is referred to as medication or drug interactions, meaning that the effects of one medication, favorable or unfavorable, may change if given together with another medication. Thus, taking five or more medications leaves many opportunities for such interactions.

Polypharmacy places a burden on patients to remember when and how to take all prescribed medications. Multiple medications increase the risks of inappropriate medication use, non-adherence, adverse effects, and medical cost. Another unwanted effect could be that physicians may hesitate to prescribe a new essential medication to a patient already on five or more medications. Thus, paradoxically, polypharmacy can lead to under-treatment. This research work aims to develop an automated anti-polypharmacy system. While the specific objectives are:

i. Design a framework for the development of the new system, which is the anti-polypharmacy system.
ii. Develop the algorithms for the development of a web-based anti-polypharmacy system
iii. Implement the algorithms by developing an online anti-polypharmacy system.

The major purpose of this work is to provide means of tackling the menace of adverse drug reactions resulting from drug prescriptions by pharmacists, doctors, and other health practitioners and consequently reduce the effects to the barest minimum.

## 2. LITERATURE SURVEY

Adverse Drug Reaction (ADRs) is the major focus in this study resulting from drug-induced morbidity, but they form only a small part of Drug-Related Problems (DRPs). Medication errors, over-dosage, drug dependence, non-compliance, and therapeutic failure are further examples of DRPs. The literature review is to evaluate previously published literature on polypharmacy which hinges strongly on Drug-drug interaction that may potentially lead to adverse drug events. Articles in medical, nursing, and pharmacology journals with an intervention, protocol, or guideline addressing polypharmacy that leads to adverse drug events. This work focuses on the problem of ignorance and information gaps that exist amongst medical professionals and how to bridge them. The variables include Drug Interactions, Adverse drug effects, prescription cascades, failure to counsel patients, self-medication, negligence on the part of the health professionals and the patients inclusive, drug abuse, and ICT-based information system. Having identified these variables, we shall be relating them to the literature to reflect their true meanings.


Alpana and Fernando (2017), their opinion fostered a change in focus from inappropriate polypharmacy, inappropriate prescribing of too many medicines, to optimal polypharmacy, appropriate prescribing of many medicines, since an individual may have many health diseases. Two main approaches were used here for intervention, during the prescription process, and post-prescription review processes. The limitations or gaps to the study include the need for Preventive interventions by the clinicians, at the point of prescribing, they should be able to prescribe after making a holistic assessment of the patient rather than a single presenting disease so that the factors raised in the review process are taken into consideration.

Another literature by Robert, Ryan & Paul, (2021), shows that the best practices for reducing polypharmacy and other high-risk medications include education about risk and an agreement between patients, their families, advocates, and caregivers. The education begins firstly by reconciling the patients' medication. Reconciling medications at transitions from hospitals and specialist clinics has been shown to reduce errors in medication.

Next is an assessment of adherence, screening for high-risk drugs and those interacting with other drugs and affecting the patient. Finally, the consultation should include an actionable therapeutic plan for optimizing medications within the patients' best interest. Another action considered effective is Deprescribing. This is the purposeful act of stopping one or more of a patient's medications i.e. Anti-hypertensives, hypoglycaemic, Anti-inflammatory, herbal supplements, and vitamins.

Arcopinto and Magro, (2017) conducted a study by the National authority responsible for drug regulations in Italy. Studies showed that every single patient needs a comprehensive assessment to give him a personalized therapy that will balance the benefits and harms and also take full account of his priorities and preferences into consideration. A computerized system was introduced to change health care provider behavior positively, improve physician's performance, and reduce drug-drug interactions and the number of inappropriate prescriptions.

The review shows that prescription error was on the increase and most mistakes were due to slips in attention, or to prescribers omitting relevant rules. Other risk factors among the doctors are workload, low perceived importance of prescribing, communication within their team, inadequate training.

The absence of key policies and procedures for polypharmacy management, hence the need for a multi-component ICT-based approach will help in addressing these issues. To address this issue, efficient computerized (interactive) prescription support systems are needed to alert the physicians on problems caused by many potential drug-drug interactions across all the possible combinations of the drugs used for chronic disease which is to be memorized by the average medical doctor or to be included in clinical practice guidelines.

The gaps in the literature review include communication gaps between the clinicians and patients, low perceived importance of prescribing, work environment, workloads, physical and mental well-being, lack of knowledge, unnecessary alerts and pop-ups, working with fewer drugs in a special case of a disease condition, and so much more in other similar applications.

Magro and Arcopinto (2017) succeeded in changing the health care provider behavior positively and proposed an algorithm to have a multidisciplinary/ multicomponent approach integrating the physicians, Pharmacists, and Nurses.

The weakness identified from the literature review includes the inability to address Potentially Inappropriate Medications (PIMs), lack of alternative medications list for patient-specific judgment, absence of key policies and procedures for polypharmacy management, and need for efficient computerized (interactive) prescription support systems to alert the physicians amongst others.

## 3. METHODOLOGY

The research methodology adopted in this research work has two major components: the system and web application development. The system development approach is the System Development Life Cycle (SDLC) which was tailored along with the design principles of the waterfall model. The client-server architecture has been used the web application development. This has been employed in developing an Application Programming Interface (API) that checks for Drug-Drug Interaction (DDI) of some selected drugs which commonly result in polypharmacy. The drugs have been selected from a Drug-Bank Database (DBD) which is a free database (of drugs) that contains data of all drugs that have passed clinical trials. The methodology defined above is shown in Figure 1.

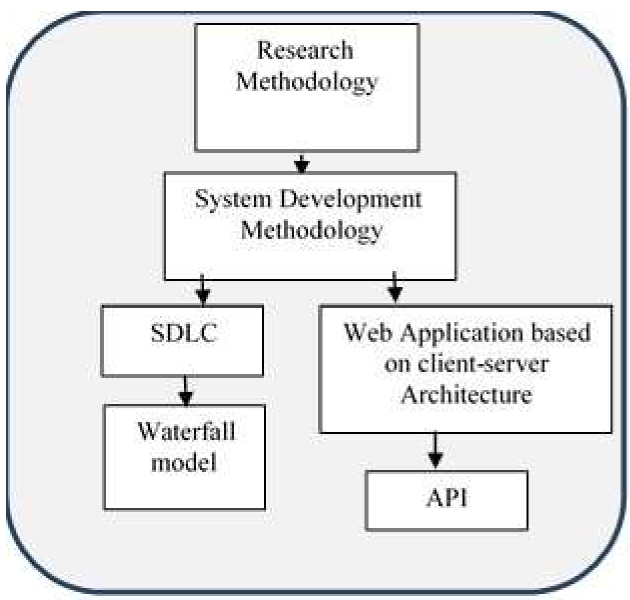


Figure 1: Aspects of the Research Methodology

This work has been implemented using the Waterfall Model. These two: SDLC and Waterfall models have been combined into one logical approach in the diagram above. The waterfall model is extensively used in software development. It has been adopted here because the major components of the work involve software design and development. The steps in the waterfall model include requirement elicitation and analysis, design, coding, testing, deployment, and implementation issues, and lastly maintenance. These steps aid the design framework for the development of a web-based application for an anti-polypharmacy system that tackles the issues as stated in the objectives.

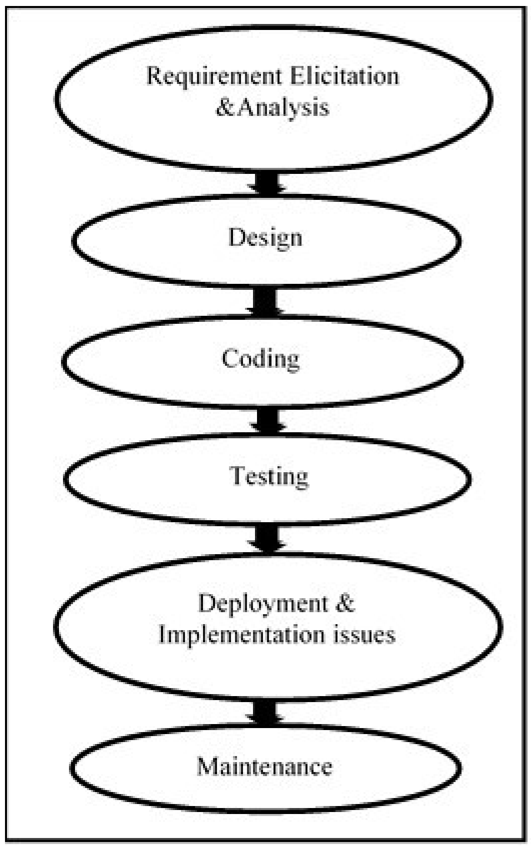


Figure 2: Adopted Waterfall Model

The activities performed under the various steps are summarized in Figure 3, while the full details are discussed next.

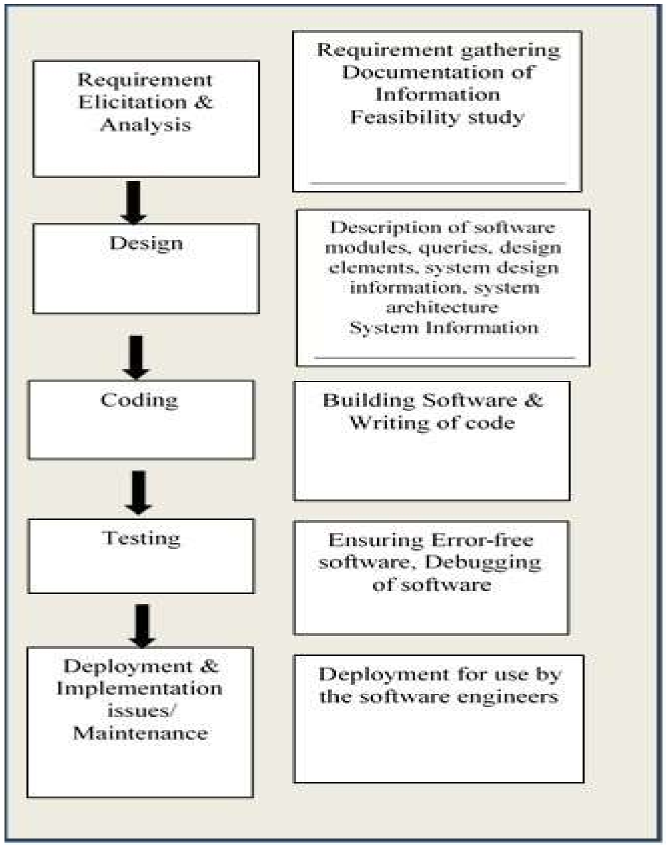


Figure 3: Activities involved in the System Development Life Cycle

### 3.1 System Design

This provides detailed information on the components of the system ranging from the architecture to the modules, hardware requirements and software to be deployed.

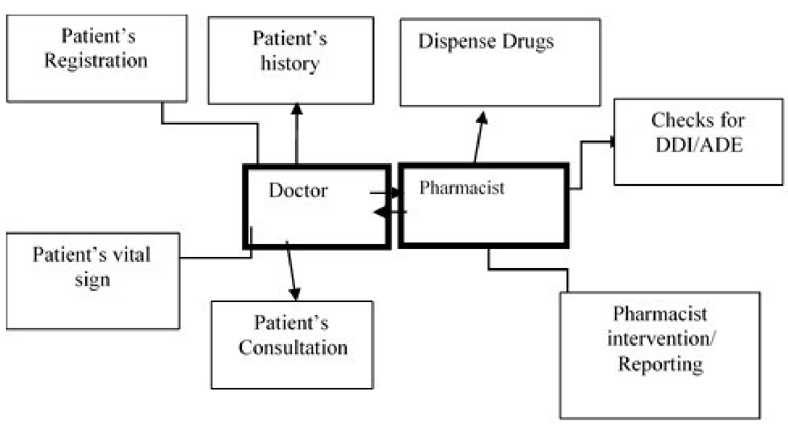


Figure 4: Framework of the New System


Figure 4 shows the framework of the new system. It describes the activities of the doctors and pharmacists in the Anti-polypharmacy system. This framework complements the modules for the new system. The features listed are modules to be developed in the new system.

i. Login Module: Each user in this module has unique login credentials.
ii. Patient's Registration Module: This module captures the bio-data of every new patient generating a unique hospital identification number automatically.
iii. Vital Sign Module: This module captures the patient's vital signs, which include blood pressure, pulse rate, body temperature, and weight.
iv. Consultation Module: This module encapsulates patients' history, diagnosis, and drug prescription modules
v. Dispensary Module: This is the core of this research. The proposed system allows the pharmacist to view the list of all prescriptions, check DDI/ADE related to each prescription, and finally decide whether to dispense or not.
vi. Patient Encounter History Module: This module provides the history of a returning patient for effective management by the doctor.
vii. Billing Module: This module provides billing services to the medical institution.
viii. Reporting Module: This module helps the health professionals query the database for information gathering.

## 3.2 Coding

This is the third step of the SDLC process. The design was implemented using codes from the following programming languages; HTML, CSS, JAVASCRIPT, PHP, and MYSQL.

## 3.3 Testing

The test data are some anti-diabetics obtained online. Examples of such drugs are metformin, clarithromycin, erythromycin, glimepiride, ritonavir, loratadine, lopinavir, saquinavir, metoclopramide, and bromocriptine. Data were obtained from an online database and the use of a questionnaire.

# 4. RESULTS AND DISCUSSIONS

## 4.1 Deployment and Implementation

The two platforms that can be used for deployment of this application are namely:

i. WAMP
W- Windows, A- Apache, M- MYSQL, P- PHP

ii. LAMP
: L- Linux, A- Apache, M- MYSQL, P- PHP.

## 4.2 Analysis and Discussion

In this work, some modules have been designed to meet the needs of the patient and assist the clinicians in discharging their duties effectively and efficiently. They include user registration module, login module, patient registration module, patient vital sign module, consultation module, billing module, dispensary module amongst others.


The function of each module in the Anti-polypharmacy system has been clearly defined and displays all the results of data entered in the anti-polypharmacy system. These modules have been designed to save the patient's information, enable the clinicians to attend to the outpatients, and dispense drugs that do not interact with each other. The modules have been designed based on findings obtained from the questionnaire.

The modules allow a registered user to log in, after a successful login, the user is being launched to the system dashboard. Here, the user either registers a new patient or search for a returning patient using the patient Hospital ID generated at registration. If a record is returned, then the vital signs of the patient can be taken, patient's bio-data are correctly collected and updated before being enrolled for consultation. Here, the doctor evaluates the vital signs taken by the nurses, takes the patient's medical history, does diagnosis,s and prescribe drugs adding their dosage as appropriate.

One of the core modules in this work is the dispensary module. The actual menace of polypharmacy is handled in this module. This module is meant for the pharmacist as they can view all the prescriptions made by the doctors. Aside from that, before the prescribed drugs are dispensed, a Drug-Drug Interaction Checker is made available to ascertain if the prescribed drugs are suitable for the patient. The other modules help to gather the patients' information as required by the clinicians for reference purposes.

## 5. CONCLUSIONS

Polypharmacy is a consequence of having several underlying medical conditions and it is commonly found in elderly patients. Aging is a natural phenomenon hence should be given adequate and due attention for each patient. The Anti-polypharmacy system will certainly help doctors and pharmacists make better and valid decisions as regards drug prescribing and dispensing without the occurrence of ADE thereby totally reducing the mortality rate that results from ADE. The system will also assist in reducing the tragedies of self-medication, aid pharmacists to dispense drugs with better options, a review of drug regimen will be readily available for further decision and put a check to the safety of marketed drugs. This will in turn will curb incessant deaths in our health institution, bridge the gap between medical professionals and patients, create awareness on polypharmacy to the users of the system and also guarantee a world-free of ADE.

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