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## **DEVELOPMENT OF A COMPUTERIZED HOSPITAL LABORATORY OPERATIONS' SUPPORT SYSTEM**

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### **Abstract**

Manual hospital laboratory operation system is characterized with lack of prompt retrieval of Information which result in time wastage, loss of information, misplacement and misallocation of results. To proffer solution to the aforementioned problems, the research study developed a computerized hospital laboratory operation support application which is aimed at using information technology to solve the problems associated with manual method of Hospital Laboratory Information System. The system is a web based model built on laravel 7.29 and a WAMP (Windows, Apache, MySQL, PHP) server. A total of 4 laboratories were visited (2 government owned and 2 private laboratories) to collect various types of tests being carried out in the laboratories through ethical approval using the conventional and the developed systems. During the implementation of the developed system at Oyo state hospital management laboratory in Oyo and Ibadan, the system was installed unto the hospital laboratories' database and subsequently utilized for registration of patients data and processed data. The result obtained showed that 65% of the respondents who were tested with the developed system used between 30-45 minutes and 48% used between 46- 60minutes while 88% that used the manual system used between 2-8hours before the result was ready. The adoption of this research will greatly allow prompt release of test results retrieval of Information, reduce patient test time wastage, give accurate laboratory test result, reduce loss of vital information, reduce misplacement

of test results and reduce misallocation of test results to the barest minimum, if not totally eradicated.

Keywords: Computerized, information technology, Hospital, Laboratory, Laravel

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## **Introduction**

### **Health Information System (HIS)**

A health information system (HIS) is a database management system for medical records. Systems that collect, store, manage, and transmit a patient's electronic medical record (EMR), a hospital's operational management, or a system that supports healthcare policy decisions fall into this category (Chris Brook, 2020). Information relating to the practices of physicians and health services is often handled by health information systems. These can be used in conjunction to optimize health care, inform research, and impact policy and decision-making. Security is a significant problem of health information systems when they often view, handle, or retain vast quantities of confidential data (Chris Brook, 2020).

Laboratory Information Systems (LIS) have been essential components of clinical laboratory operations since the 1970s (Sepulveda & Young, 2013). Originally, they were designed to collect, register, present, organize, and archive experimental findings, with an emphasis on producing data for proper laboratory financial management (Sepulveda & Young, 2013). Although information technology as a whole is progressing at a faster rate, especially in the hardware domain but also in software development, LIS has not remained consistent. Health care systems in general can be characterized as conservative and resistant to change and current health care information systems (HIS) and LIS are a reflection of this conservative approach. This LIS is a computer system that aids in the management of many areas of a medical laboratory, such as inputting, processing, and storing data and information. It is a computer-based data processing system designed especially for labs. Although supporting the laboratory mission, a LIS is used to facilitate laboratory workflows as well

as serve as a repository for laboratory data and they are usually used in standard reports.

### **Computerized Hospital Laboratory Operations System (CHLOS)**

A computerized hospital laboratory operation system is a type of health information that is primarily concerned with laboratory administration. According to RA (2017), a CHLOS is a comprehensive information system designed to manage all aspects of laboratory operations, such as blood tests, urine tests, and the corresponding processes of services, in many implementations. The laboratory's management is concerned about the growing effort required to maintain patient laboratory records and diagnoses. The use of a computerized hospital laboratory operation system, which can store patient and employee records as well as medical test results. It can also be capable of effectively managing the patient assessment track and patient reviews (Yuriy, 2020)

### **Statement of the Problem**

Manual processes involved in laboratory test retrieval, update and storage of information has led to loss of important data and wastage of appreciable time. Manual Laboratories systems are characterized with lack of immediate retrieval of Information which most of the times is very difficult to retrieve and to find a particular information from large junk of files which result in time wastage. Also, information generated by various test results takes time and effort to be stored and sometimes when stored manually, many vital information are lost and even cases of misplacement of results and misallocation of test result may emerge in the process. Prompt and accurate updating of various information like patient test results are difficult to make as paper work is involved. Hence, the development of hospital laboratory operation system support application which is aimed at using information technology to solve the problems associated with manual method of Hospital Laboratory Information System.

### **Aim of the Study**

The aim of this project is to develop a hospital laboratory operations support system

### **Literature Review**

Computerization is the method of transforming manual operations to digital-based operations through the use of computer software. Additionally, it can be described as a method of automating manual processes in various sectors to allow them to perform their duties more efficiently and accurately, thereby reducing stress and delays associated with performing their duties efficiently. As viewed through the lens of the modern world, it is critical to have a computer-based system in place to handle manual calculation, which can be considered a human-based capability, and to reduce bulky paper work, time constraints associated with control activities such as processing, increase productivity, avoid data redundancy, and reduce paper work and data processing. Several researchers had worked on digital-based operations in health sector. Thus, Scott-Clark (2022) expressed a health information system (HIS) as a means to manage the data collected and stored in a healthcare facility which includes physician practices, private and public clinics, and hospitals and that these facilities collect, store, manage, and send patients' electronic medical records. Digital health systems improve patient treatment with the most current patient data available and patient data is highly sensitive, so any health information system used must ensure the accuracy of data collected and patient confidentiality ( Scott-Clark, 2022). In another vein, Rybkin(2020) opined that Hospital Management System (HMS) is a software that stores all information regarding the activities of a medical institution, including financing, administration, patient admission, doctors workload, appointments, and so on. This implies that the system is developed to also stores users' medical data and other related information that will enable medical personnel to attend to their customers with little stress. The use of HMS allows medical institutions to optimize routine manual tasks, unload and organize workflow, reduce administrative costs and the human error factor. Computerized clinical decision support

systems, or CDSS, represent a paradigm shift in healthcare today which are used to augment clinicians in their complex decision-making processes (Sutton, *et al.*, 2020). Thus, CDSS is intended to improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information (Sutton, *et al.*, 2020).

### Laboratory Data Management System

The Laboratory module is a web-based electronic platform with a high degree of usability and ease of use that is used in single clinics and polyclinics (Alanazi, 2015). It is a comprehensive management system that manages all aspects of the business, from patient management to results generation and physician decision-making. The framework allows simple data interaction as well as the ability to update data. It is one of the most dependable systems in terms of placing orders and then delivering accurate results stored in databases. Alanazi, (2015). emphasized that additionally, the device communicates with and shares data between hospitals and clinics about (the status of infection, immunology, and treatment and patients' medical status.



**Figure 1: Departments linked with the LIS system  
(Source: Speedpath, 2018)**

### LIS Requirements

When developing processes for labs, hospitals, and private clinics, it is essential to consider what ensures job efficiency and process completion. There are measurements and criteria that assess the whole system, as well as tests that assess individual components. These discrete components are either software or small networks that are integrated into the system. A group of experts may decide to establish clear criteria for evaluating laboratory systems' performance. The primary objective of these standards is to achieve high management performance, protection, and a low rate of errors. There are five primary criteria for evaluating a system, and numerous additional criteria for evaluating specific aspects of the system, such as user satisfaction, consistency, scalability, and usability(Alanazi, 2015).

### LIS Constraints

Each framework presents unique challenges that can be investigated, created, and suitable solutions discovered. To begin, since the system is highly powerful, complex, and interconnected with other systems, it is extremely difficult to correct errors. When a system malfunction prevents workers from understanding and repairing it, they must connect with the company to request a team to resolve the issue. Certain issues take a long time to resolve, especially if the system is interconnected with other systems, resulting in crashes and overstock in patient outcomes(Alanazi, 2015).



**Figure 2: LIMS procedures**  
(Source: Speedspath, 2018)

## **Methodology**

The system is a web based model built on laravel 7.29 and a WAMP (Windows, Apache, MySQL, PHP) server. All the code structure follows an MVC (model-view- controller) coding standard so every action has a model, a view and a controller; the view is the HTML and JavaScript codes. MVC is a software architecture that separates domain/application/business logic from the rest of the user interface. It does this by separating the system into three parts: the model, the view, and the controller<sup>1</sup>. Also, Laravel is a PHP-based web framework that is largely based on the MVC architecture (blog.pusher.com).

The developed system processes are

1. Admin Registration
2. Log In
3. Add Client
4. Take Test
5. Send result via real time email notification

## **Admin Registration**

This is where the admin registers to have access to the design. The page has provision of the name, email address, password, confirm password and the register tab. This authenticates the Administrators. If the user of the system is valid, it allows the user to enter into the system and use the system. Alerts when unauthorized users try to access or manipulate the system. The Register page was designed using the snippet code below.

```
section('content')
<div class="container">
  <div class="row justify-content-center">
    <div class="col-md-8">
      <div class="card">
        <div class="card-header">{{ __('Register') }}</div>
```

## **Login Page**

Here, the admin login in with his/her login parameters. Once the admin is logged in, a dashboard page pops up. The dashboard consists of the client,

test and result. Also, the client name, phone number, action, take test, view profile and add client tab. Here the admin will be able to either perform vital actions based on the preference of the client or patient. The Register page was designed using the snippet code below.

```
@extends('layouts.app')
@section('content')
<div class="container">
  <div class="row justify-content-center">
    <div class="col-md-8">
      <div class="card">
        <div class="card-header">{{ __('Login') }}</div>
```

### **Add New Client**

New clients are added via the add new client tab to fill up the information of the new client which include the name, email, phone number, sex and date of birth. The record was stored in the database and can be recalled anytime it's needed. The add client page was designed using the snippet code below.

```
@extends('layouts.admin')
@section('title')
  MedLab
@endsection
```

### **Add Test**

This is where the test to be taken is added. Once the admin clicked add new test, a new window showing add new test page pops up. The add new test consist of the test name (For example , HIV test), the test type (blood or urine or oral fluid ), the number of parameters to be checked depending on the type of test. For HIV 3-4 parameters are checked (**NATs which** look for the actual virus in the blood, **Antigen/antibody tests** look for both HIV antibodies and antigens, **Antibody tests** look for antibodies to HIV in your blood or oral fluid) (CDC, 2013). Then the add test tab was clicked to give the details of all the parameters. The take test was designed using the snippet code below.



```
extends('layouts.admin')
@section('title')
    MedLab
@endsection
@section('styles')
<!--
- <script src="https://cloud.tinymce.com/stable/tinymce.min.js"></scrip
t>
    <script>tinymce.init({ selector:'textarea' });</script> -->
@endsection
@section('page')
<a href="{{url('/addclient')}}">Add New Test </a>
```

Hence, once the result is ready, the test name and the corresponding result will be imputed and submitted. Once it is submitted using the submit result tab as shown in figure 6, it can now be viewed on the dashboard in figure 3.3 using the view profile tab.

The client information can also be viewed on the user information page. This can enable the admin confirm the identity of the client before sending a real time email to the mail address. It can be useful for editing and updating of client information.

### **Real Time Email Notification of Test Result**

After the result of the test had been generated, an email notification will be sent to the client email by clicking the send mail tab. Hence, a client or patient may not need to wait after the test, once the result is sent to the mail, the client can print directly from the mail and present to where ever it may be needed. This will greatly reduce the client waiting time. The snippet code to generate email notification is shown below.

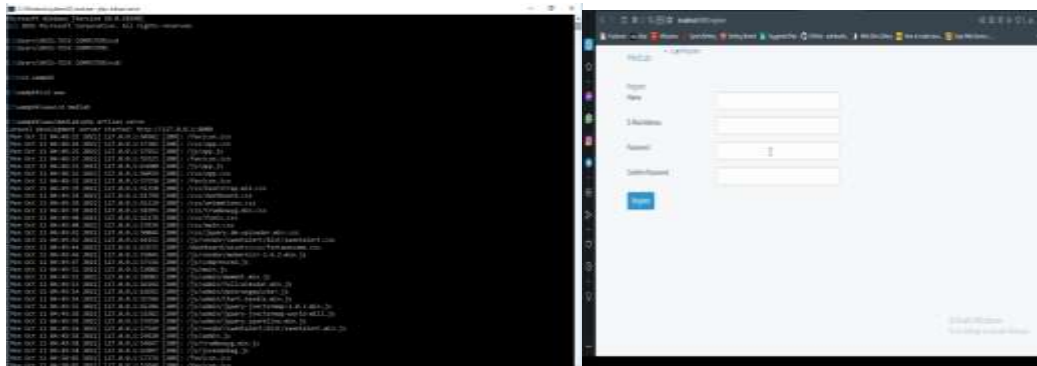
```
public function senattach(Request $request){
    header('Content-type:application/json;charset=utf-8'); //email rid
    $email = $request->email;
    $rid = strip_tags($request->rid);
    // File::move($image, public_path("pipeline/"));
```

```
// $this->mailmag("pipeline/", 'test.png');  
//$pdf = base64_decode($image );
```

## Result

### Results on the Development of a Computerized Laboratory Support System

A command “PHP artisan serve” was written on the command prompt to start the local host as shown in figure 3. Also, the server (WAMP) must be running on background and connected to the internet. Once this is done, the local host address was typed on the address bar of the browser so as to open the designed software showing the registration and login module as shown in figure 4



**Fig.3: Admin registration page and “php artisan serve” command written to start the local host**

### Result of Admin Registration Page

This is the area where the administrator registers for access to the design. The page contains fields for entering the user's name, email address, password, and confirm password, as well as a register tab (see figure 5). This verifies the Administrators' identities. If the user of the system is valid, the user is granted access to and use of the system. It also sends notification when unauthorized users attempt to gain access to system.

### Result of Login Page

The dashboard is divided into three sections: client, test, and result(s). Additionally, there are tabs for the client's name, phone number, action,

take test, view profile, and add client as illustrated in figure 6. The administrator will be able to execute critical activities based on the client's or patient's preference.

### Result of Add New Client Page

New clients were added using the add new client tab, which allows to populate the new client's information, which includes their name, email address, phone number, sex, and date of birth, as illustrated in figure 6&7. The entry was saved to the database and can be retrieved at any time.

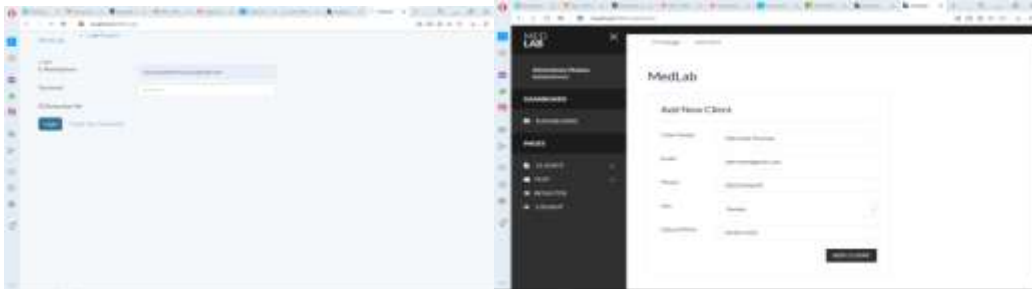


Fig. 5: login page

Fig.6: add new client/dashboard page

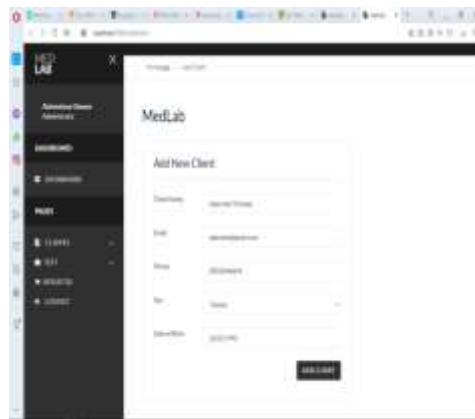


Fig.7: add new client page

### Add Test Page

This is the section where the test to be administered is added as illustrated in figure 6&7. After the administrator clicks add new test, a new window displaying the add new test page appears. The add new test command specifies the test's name and the number of parameters to be verified, which varies according to the test's type. For the implementation, the test

type is Malaria, where haematology is the test name which have 15 parameters. Then, the add test tab was clicked and a page showing success of the test added popped up as shown in figure 8, 9 and 10

Immediately the test is conducted, the values for each parameter will be inputted. For example, if the body temperature of the client or any other results, is 36.7°C, it will be detailed in the result module of the take test page after which a page pops up showing the success of the new test result submission. This can now be accessed via the view test tab on the test taken page of the dashboard as shown in figure 11 which will have the test id, test name and date. Additionally, the client information can be read on the user information page which enables the administrator to verify the client's identity before to sending a real-time email as illustrated in figure 12. It might be advantageous for changing and updating customer data.



Fig. 8

Fig. 9



Fig.10

**Fig 8, 9&10: Snapshot of add test page of computerized laboratory support system**

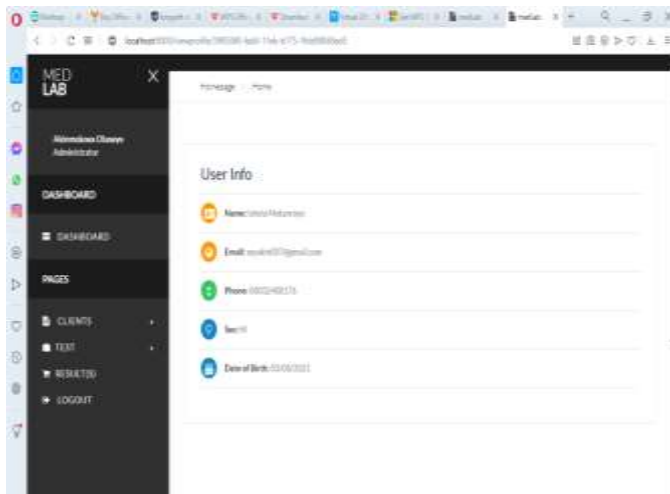


Figure 11: view test page

After the test was conducted, completed and saved on the database, an email notification of the result showing the test type, date, time and all parameters with units was sent to the client's email address via the send mail tab as illustrated in figure 12(a) and 12 (b) respectively.

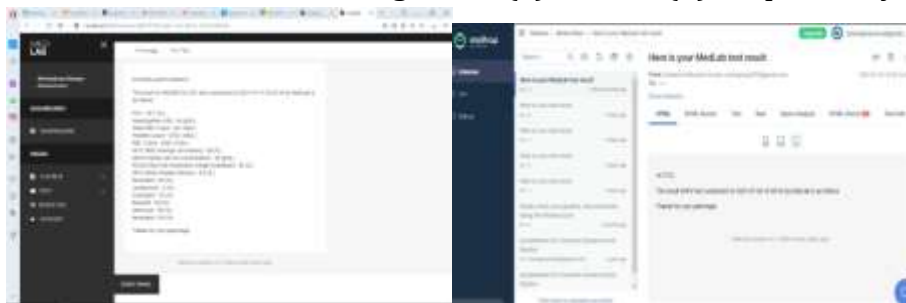


Fig. 12(a) test result

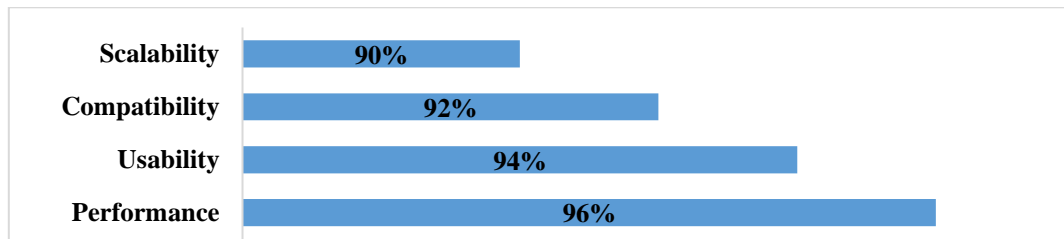
Fig. 12 (b) email notification of test result

## Result on Evaluation of the Developed Application

Table 1: Evaluation Table of the Developed Application

S/N	Test Type		Score (%)
1	Performance	i. Response Time	95
		ii. Reliability	93
2	Usability	i. Easy to Understand	95
		ii. Easy to Access	93
		iii. Effective Navigation	95

3	Compatibility	i. Software	95
		ii. Hardware	90
		iii. Network	90
4	Scalability	i. Throughput	90



**Fig.13: Performance Testing**

### Discussion of Findings

The developed computerized laboratory support application is a web based model built on laravel 7.29 and a WAMP (Windows, Apache, MySQL, PHP) server running on the background. The developed system comes with the ability to add clients details, take test, and send test results via to the clients email as shown in figure 3, the “php artisan serve” command was written there by starting the developed server. Once the developed server starts, the web based application begins typing “local host 8000” on the internet address bar which in turn leads to the login in page of the application. Figures 4-12 show snapshot of the implementation of the developed system where the admin registers and log in, add client after which the client can go ahead to take test and the test parameters are saved on the database for retrieval. Evaluating the design as shown in figure 13 at a chosen manual driven laboratory, the design was tested by a software test engineer and a web developer. The test is based on performance (Response Time, Reliability), compatibility (software, hardware), usability (easy to understand, easy to access, effective navigation) and scalability. The design was used to generate real time notification results of test conducted.

## Conclusion

Different tests were conducted and the result of the tests was sent real time to clients email addresses. Also, the speed of transmission to the email depends on the strength of the network. The system had a good response time, scalability and reliability. However, response time is dependent of the network used for internet. For this research, the test results were sent immediately and received in the email. Hence, the system provided a simple, cheaper and durable computerized hospital laboratory operations system. The major limitations of this research were the internet network connection and internet speed. The developed application is based solely on good and efficient network for prompt and effortless transmission and connectivity. Email result was simulated using a paid email address (Mail Trap) as gmail flags a security breach alert on every mail sent, blocking the receipt of mail in the gmail address.

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