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Designing an Electronic Blood Analysis System

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ABSTRACT

Background:

The primary use of this tool is to assist in calibrating the degree of clinical suspicion for a diagnosis, aiding in either confirming or excluding it. Additionally, it is employed for the purpose of illness monitoring. The amount of clinical suspicion and the probability of a specific test result might be positively associated in practical terms.

Materials and Methods:

The proposed method used to build the website is Visual Studio 2015 with SQL server Database to provide the possibility of electronic interaction and communication between the patient and the laboratory official, through prior online reservation and it is possible to create an account for the patient as well, allowing him to access information about blood analysis within the laboratory as well as the ability to print the report in the form of a paper report.

Results:

The proposed system website provides the ability to test blood for eight of the common blood test methods, represented by the following tests: Knowing the blood type (ABO), white blood cell count (WBC) / red blood cell number, platelet count, erythrocyte sedimentation time (ESR), estimation of hemoclopane (HB) to sixth experiment, hematocrit determination (PVC), The seventh experiment measured bleeding time (BTE).

Conclusion:

The current study is able to provide fast, accurate, and detailed analysis of blood samples without the need for manual processing and it leads to cost savings for healthcare facilities in the long run.

Key words: Blood Test; Knowing the blood type (ABO); Web; ASP.NET; Laboratory Analysis.

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INTRODUCTION

Laboratory testing is the most often performed medical activity. The primary use of this tool is to assist in determining the likelihood of a diagnosis, either confirming or ruling it out. Additionally, it is utilized for the purpose of tracking the progression of a condition [1]. Practically, there is a correlation between the amount of clinical suspicion and the probability of a specific test result. If the suspicion is stronger, there is a greater likelihood that the result will confirm the diagnosis. The test result may be influenced by the information that contributes to the clinical suspicion, such as the patient's age, gender, previous diagnoses, and previous laboratory findings [2].

Essentially, this connection may be utilized to enhance laboratory testing by allowing for the estimation of the likelihood of obtaining a specific test result before actually ordering the test. Ultimately, this can lead to a reduction in the use of tests without negatively impacting patient outcomes. Ordering fewer tests, where appropriate, might improve outcomes by sparing patients the inconvenience of dealing with incorrect positive or negative results [3].

In practice, the connection between clinical suspicion and pre-test likelihood is regularly employed to establish guidelines on when to conduct a certain test and when not to. For instance, the first likelihood of Lyme serology test showing positive results when there is a target ID rash is so high that, considering the test's sensitivity and specificity, it is not recommended to order the test [4]. Given the abundance of tests and clinical situations, as well as evidence from various medical fields suggesting that laboratory testing can be enhanced, it is important to determine whether analyzing extensive clinical databases using reliable statistical methods can convert this correlation into practical decision-making rules. Alternatively, it is worth exploring other avenues for improving laboratory utilization [5].

Examination of patient samples using an Electronic Blood Analysis System to provide comprehensive examination of entire blood samples [6].

1. Specimen Criteria: Acceptable Samples The sample required is fresh whole blood, either arterial or venous, obtained using a syringe containing 1, 2, or 3 millilitres of lithium heparin. IRMA cartridges are generally compatible with most regular ABG syringes. For ionized calcium testing, it is advisable to use balanced or low-volume heparin. Although sodium heparin can be used, it may cause sodium readings to increase by 1 to 2 mmol/L [7].
2. Capillary samples must be obtained using the IRMA Capillary Collection Device in order to meet the requirements [8].
3. Sample Size

   - The minimal volume of whole blood required for testing is 200 µL when collected in a 1 mL syringe and 125 µL when collected in an IRMA Capillary Collection Device. Make careful you gather a enough sample to fulfil the minimum volumes necessary for injection into the cartridge [9].
4. Guidelines for Collecting Samples in General [10]
   - Schedule the collection of samples in a way that minimizes the time between collection and analysis.

- To avoid the sample from being diluted by IV fluid, it is advisable to refrain from collecting samples from above an IV line [11].
- Prior to sampling from an indwelling line, it is important to back-flush and clean the line of IV fluids in order to eliminate anticoagulants or drugs that might potentially affect the accuracy of the test findings.
- After cleansing the blood collection site with alcohol, it is important to let it dry in order to prevent hemolysis [12].
- Fill the collecting device to the suitable capacity. Insufficient filling can lead to elevated heparin to blood ratios, resulting in decreased ionized calcium levels and potential impact on other test outcomes [13].
- Ensure a comprehensive blending of the samples obtained in the syringes [14].
- Capillary samples must originate from a location that has been arterialized and the flow of blood should be unrestricted. To prevent inaccurate findings due to dilution of analyses or hemolysis, it is important to refrain from vigorous squeezing of the puncture site. [15].

5. Management of Blood Gas Samples [16]
   - Remove any air from the syringe promptly after collection and before to mixing the sample. When separating a portion of the sample for additional tests, it is important to avoid exposing the sample to air. If a sample cannot be analyzed within a time frame of 5 minutes from the moment of collection [17]:
   - Remove all air from the syringe [18].
   - Preserve the blood gas sample by immersing it in a mixture of ice and water [19].
   - Prior to injection, ensure full mixing of the sample while the cartridge is undergoing calibration [20].
6. Handling of Electrolyte Samples [21]
   To minimize any potential impact on the ionized calcium concentration, it is recommended to analyze a blood sample within 20 minutes of collection, as this timeframe helps to prevent pH changes. [22].
7. Injection of a sample
   Prior to sample injection, the cartridge undergoes automated calibration for each test [23]. After calibration, the calibrant in the sample stream must be fully replaced with the blood sample under analysis. The sample route refers to the specific region within the cartridge that contains the sensors and requires full saturation with blood [24]. Adhering to the correct sample injection method will guarantee the full displacement of the calibrant and prevent the introduction of any air bubbles during the injection process. If there are calibrants or bubbles in the sample route after the initial sample injection from a syringe, the user can

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remove them by injecting more sample from the same syringe. This mitigates sensor inaccuracies and minimizes the risk of sample misplacement. [25].

The blood analysis system described as [26] has several benefits. [26]:

1. Provided information about the implementation of a new decision support module for blood ordering, which has led to enhanced adherence to transfusion standards and subsequent cost reductions.
2. Accessibility
3. Included specific information on the expenses and benefits linked to the implementation of the recently introduced blood ordering decision assistance module.
4. Included specifics on the deployment of the decision support system.
5. In order to enhance the efficacy of hospital blood transfusions, many measures may be taken. These include expediting the availability of blood for urgent cases, minimizing the time spent by personnel in verifying blood, reducing wastage, and minimizing overall blood usage.
6. The hospital transfusion procedure underwent enhancements to ensure safety, resulting in a reduction in mistakes [27].

The major contributions of this article are represented by providing Accelerate clinical decision making, Streamline patient-testing workflow, simplify inventory management and Deliver real-time results and reporting.

RELATED WORKS

The most related works in term of design electronic blood analysis system have been discussed and overviewed as follow:

The authors in [28] developed a self-strained microfluidic device that efficiently separates 99.7% of the plasma in under 6 minutes. The optimization of parameters, such as flow rate, design of the filter trench, and the relative placements of the filter trench and channel, was achieved by meticulous microscopic monitoring. Furthermore, this gadget utilizes an affordable and user-friendly heating strip to provide a low-pressure condition in the micro-channel within a short period of time. Given the aforementioned benefits, this blood separation device might serve as an alternative platform for point-of-care testing.

In [29] they provided a portable blood analysis device that utilizes a disposable cartridge and a handheld reader. The platform has the capability to carry out all the necessary steps for a clinical test, including sample preparation, detection, and trash collection. To showcase the effectiveness of this method, a CD4 T cell enumeration was conducted. A portable CD4 T cell system was created for point-of-care use. We will specifically discuss a pneumatic technique that actively pumps and controls fluidic actuation on the chip. The reagents used in the CD4 T cell counting test were dehydrated onto a reagent plug to minimize the requirement for refrigerated storage when utilized in the field. In [30] a Self-powered Integrated Microfluidic Blood Analysis System (SIMBAS) is presented. The system is capable of extracting blood plasma from a volume of less than 5 µL of whole blood, and it can execute a multiplexed sample-to-answer assay with picomolar sensitivity. Notably, the system achieves these functions without the need for any external pumping mechanisms. The gadget incorporates all its components into a single structure and the entire test is carried out within a time frame of 10 minutes.

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In [31]An electronic blood pressure meter consists of several components: a cuff, an inflation control unit, a pressure detection unit, a blood pressure calculation unit, and a target changing unit. The inflation control unit regulates a pump that increases the pressure in the cuff at a specific inflation speed determined by a driving voltage. The blood pressure calculation unit uses the detected cuff pressure signal to calculate the blood pressure value, taking into account the pulse wave. The target altering unit adjusts the inflation speed goal in order to maintain the driving voltage within a certain range that corresponds to the pump's output capability during the inflation process.
In [32] presented a novel algorithm for the Electronic Opinion Analysis System (E-OASL) at a university library. This algorithm is capable of analyzing user opinions on the library and classifying them into categories like as positive, negative, neutral, and suggestions. The system also displays the proportion of each categorization as the output. The system we propose utilizes a hybrid approach to sentiment analysis, combining a rule-based classifier from machine learning with a corpus datastore from the lexical approach. In order to develop our algorithm, we had to gather around 1200 sets of raw data from various categories of users utilizing the university library. The system incorporates the MySQL database to enhance data processing speed and efficiency.
In [33] they identified six interface attributes. Utilizing conjoint analysis, we constructed 16 representative design scenarios based on orthogonal design by combining different attribute levels. They invited 187 elderly participants to evaluate these scenarios. Data analysis was performed using SPSS 26.0. The results indicate that among the ePHR interface design attributes, the elderly prioritize color attributes, followed by the notification method.
The results showed the evaluation of the E-OASL which showed satisfactory result of effectiveness and efficiency of EOASL compare to manual opinion analysis approach.
In [34] they described the development of a provider-facing hypertension management platform. They enumerate key steps of the development process, including needs finding, clinical workflow analysis, treatment algorithm creation, platform design and electronic health record integration. The application design and development stage were aided by a team of approximately 15 specialists in the fields of primary care, hypertension, bioinformatics, and software development.

MATERIALS AND METHODS

There are many steps for building the used website and we will summarize the main points and the then explained the used code for these steps as : Building the design with ASP.NET C# programming language with CSS for building style and SQL data base for building data sources. Adding the main libraries in ASP.Net C# programming language and establishing the main connection to SQL data base. Add comment in advice page code behind. Building Login code behind with button sign in. Account management (add account-delete account for admin lab and patient accounts). Show reservations page as Link Delete Click. View comments by admin account and admin lab sign with permission.

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Figure (1) showed the site management credentails.

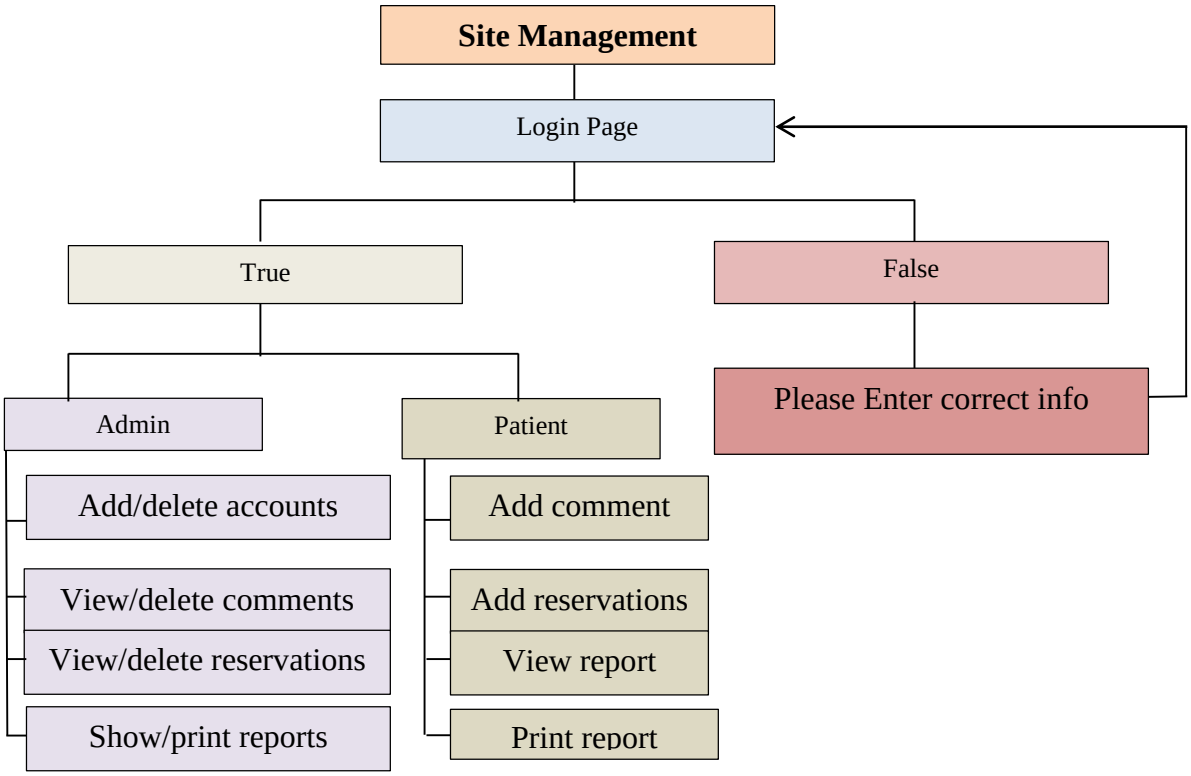

Figure (1): The main diagram for the website operation.

The types of experiments that you can perform on our website and also obtain the report of your test when entering your triple name and title in the search field, as follows:

1. Initial encounter with understanding of blood group (ABO). In the initial trial, ABO will sanitize the thumbs, penetrate the area using a medical needle, extract three blood drops, introduce the specialized substance, observe the clumping reaction, and record the blood type along with the two resulting outcomes.
2. The second experiment involved measuring the white blood cell count (WBC). This experiment aims to determine the severity of bacterial and viral infections in individuals, with the exception of situations when there is a significant rise in white blood cell count, beyond 50 thousand.
3. It involves puncturing the finger after sterilization to draw blood using a specialized tool. The blood is then mixed with a dilution fluid through gentle shaking. A drop of the mixed blood is placed on a special slide to detect blood disorders and anemia.
4. It involves drawing blood from a vein using a medical needle. A set amount of blood is obtained and then a dilution fluid is added in a given amount. The mixture is then left to react for a specified period of time..
5. Fifth Experiment Measuring time of erythrocyte sedimentation (ESR): In this experiment, blood is drawn to a specific amount, adding a special dilution fluid,

and waiting for a specific period to find out the result. This test is used to detect rheumatic diseases and arthritis.

6. Calculating the proportion of hemoclopane (HB): In this experiment, the finger is punctured after undergoing sterilization and a certain amount of blood is drawn. Subsequently, a predetermined quantity of dilution fluid is injected after a specified duration to compute the final outcome. This experiment is utilized for the detection of anemia or elevated blood levels.
7. It involves determining the hematocrit (PVC). The finger is entrusted with a specialized instrument to extract a precise quantity of blood, which is then deposited into specialized apparatus. After a designated duration, the outcome is computed.
8. It involves the measurement of Bleeding Time (BTE). In this experiment, we puncture the lower part of the ear at a specific distance. We then observe and measure the time it takes for blood to start flowing. After repeating this process multiple times, we observe that the bleeding eventually stops. The objective of this experiment is to determine the duration of normal and abnormal bleeding, as well as to identify any hereditary blood disorders.

The main design of the website build with the ASP.net and it programmed with C# programming language which is showed in Figure (2).

Figure (2): The proposed main design in the current study.

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The proposed system depended on a set of standard specifications to work optimally and obtain the desired results, as shown in the Table 1.

Table-1: Environmental requirements in the current study.

Operating Systems	*Windows 10 pro, 64-Bit*
CPU	*Core (TM) I7*
RAM	*8.00 GB*
Implementation Tools	*Visual Studio 2015*

RESULTS AND DISCUSSION

This section showed the implementation of the used website for Blood analysis as a process in which a laboratory analysis is performed on a blood sample and is usually taken from a vein in the arm using a syringe or by pricking a finger with a needle. Blood tests are used to determine the patient's physiological and biochemical status, such as detection of any disease, mineral content in the body, drug efficacy and organ function. It is also used in drug detection testing. Although the term blood analysis is used, most routine tests of this type (except those in the field of hematology) are performed on plasma or blood serum, rather than blood cells. Figure(4) shows the home page design which contains on the general information about the website and the used link and page as in Figure (3):

Figure (3): The main page home page component .

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Besides, the Tips and Advice page show the general information about the blood testing and another feature for add comment for patient or site visitor who want to make blood test and so on. Figure (4) shows the tips and advice page.

Figure (4): Tips and advice page in the current study.

While, Figure (5) shows the add comment with the details as the name, email, mobile number, and description. The inserted information redirected to the website admin or lab manager to reply to open rule dates for appointment a test within on demand of patients.

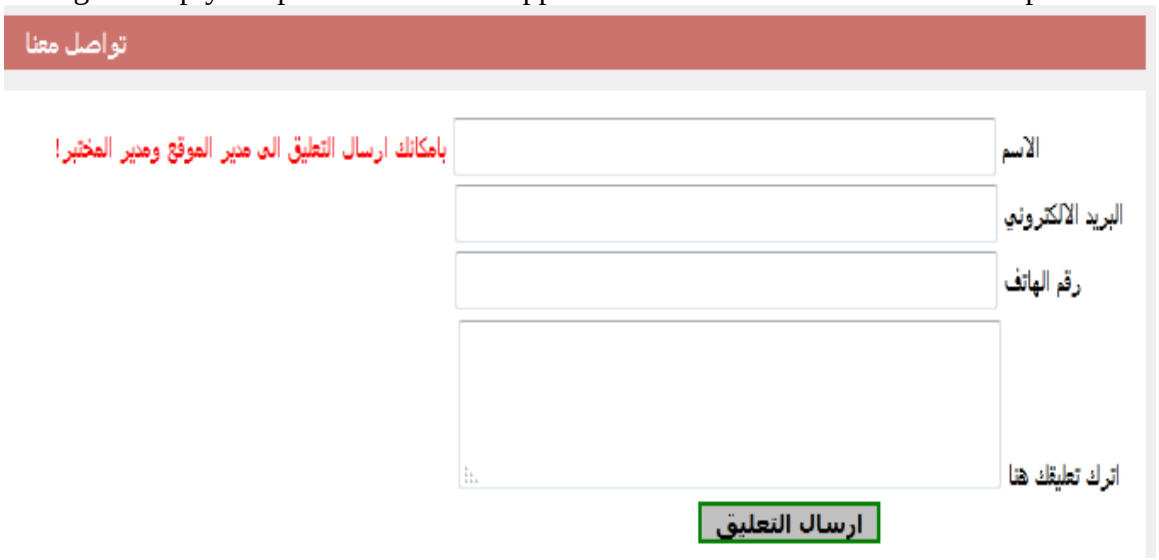

Figure (5): Add comment service in the current study.

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When the user clicks on the Reports page, he/she should login first and then page redirect to the specific page depending on the login information as admin login information or patient login information. Figure (6), shows the login page details.

Figure (6): Login page in the current study.

When the user login as the admin account it will appear as in Figure (7).

Figure (7): Admin website tools with Login page in the current study.

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While the page of show reservations, contains on all reservations and admin can delete after reading them. Figure (8) describes the reservations from patient.

Figure (8) : The show reservations in the current study.

View comment feature in admin lab to see comments on the website and also to see request from new customer not previous website user like patient. Figure (9) shows the view comment service.

Figure (9) : The view Comments in the current study.

When user sign in as the site manager or lab manager it will appear like in Figure (10) to enter new patient information to make new test.

Figure (10) : Enter new patient information in the current study.

Figure (11) shows an example for create new blood test for patient with personal information as follow :

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Figure (11): Creating new experiment blood test patient account in the current study.

Figure (12) : Save created patient information in the current study.

When admin lab clicks on the start the test it will appear like in Figure (13) as the 8 blood test experiment with the different features depending on the requirement for each test and then click save results and show report.

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Figure (13): the used 8 experiment for blood test in the current study.

While Figure (14) shows the result button for each case as depending on the provided features for the system.

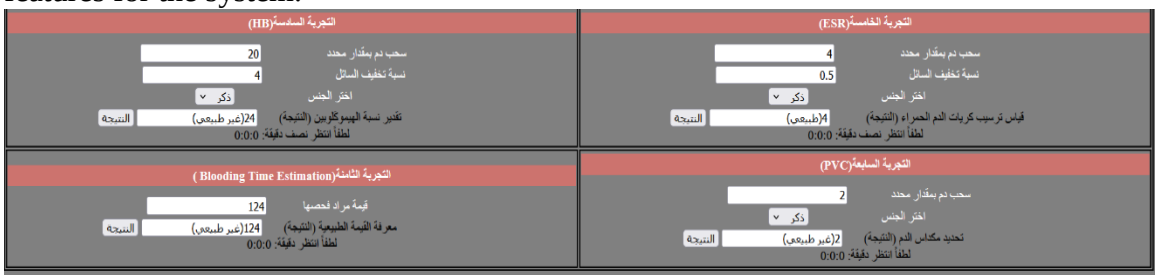

Figure (14) : The result button for each case in the current study.

The final result page shows the final report for the blood test and depending on the all selected experiment selected through the check page or create new blood test page and the admin can be searching on specific patient name or the patient state in addition the admin can print the report with the printer for patient as it showed in Figure (15), Figure (16).

رقم التجربة	نتيجة ABO	نتيجة WBC	نتيجة RBC	نتيجة PLT	نتيجة ESR	نتيجة HB	نتيجة PVC	نتيجة BTE	اسم المريض	عمره	اسم التجربة	تاريخ الادخال	محل السكن
45	A-	8000(طبيعي)	2610000(غير طبيعي)	4000(غير طبيعي)	4(طبيعي)	24(غير طبيعي)	2(غير طبيعي)	124(غير طبيعي)	قاسم علي محمد	23	ABO	PM 9:53:23 4/26/2024	بابل

Figure (15): Final report in the current study.

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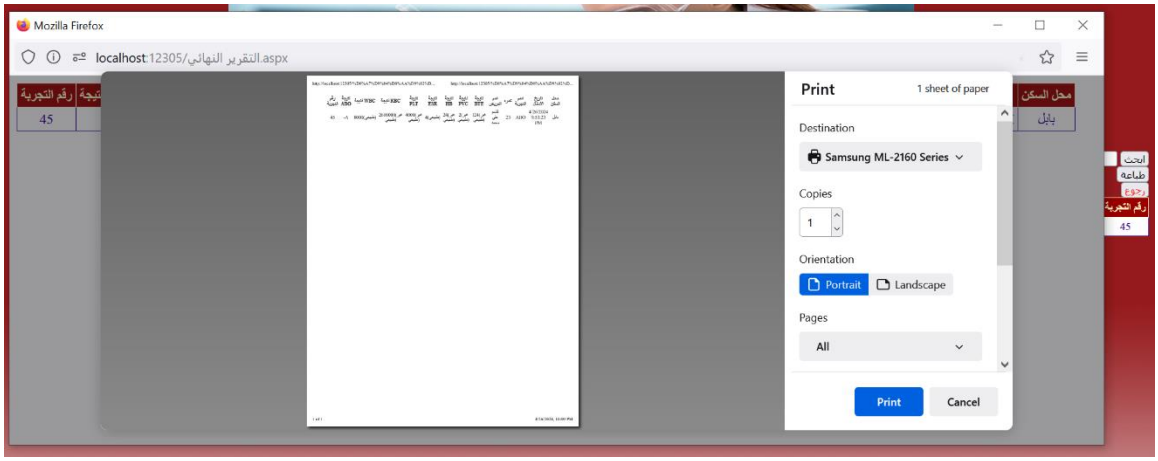

Figure (16): Print the final selected report in the current study.

Figure (17): Another example for patient report in the current study.

Figure (18): example for searching about patient name in the current study.

While the registration with the login page as the patient account toy can get these service as if you have previous blood test data you can just search about your name to searching and get your information and also can view the report and then print or if you are not having a previous testing case you can click on the appointment booking, as it explained in figure (19-22).

Figure (19): services for patient account in the current study.

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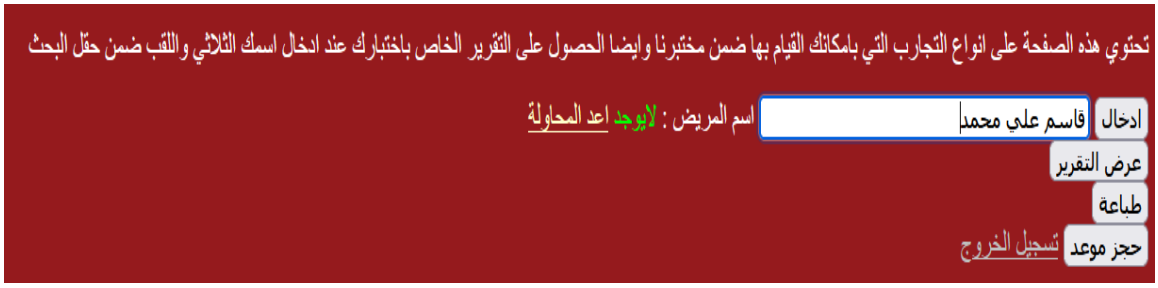

Figure (20): searching about name and state of patient in the current study.

رقم التجربة	نتيجة ABO	نتيجة WBC	نتيجة RBC	نتيجة PLT	نتيجة ESR	نتيجة HB	نتيجة PVC	نتيجة BTE	اسم المريض	عمره	اسم التجربة	تاريخ الادخال	محل السكن
45	A-	8000(طبيعي)	2610000(غير طبيعي)	4000(غير طبيعي)	4(طبيعي)	24(غير طبيعي)	2(غير طبيعي)	124(غير طبيعي)	قاسم علي محمد	23	ABO	PM 9:53:23 4/26/2024	بابل

Figure (21): view the report for patient in the current study.

Figure (22): Send new request for the new blood test in the current study.

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In case of test date is saved for patient the system showed it saved in Figure (23).

Figure (23): Send registration request in the current study.

Otherwise, the patient can make a book an appointment for new date with the test date of registration option as showed in Figure (24).

Figure (25) : Send book free appointment request in the current study.

We will explain the component for each data base table in asp.net c# SQL data base as follow:

1- Admin login table :

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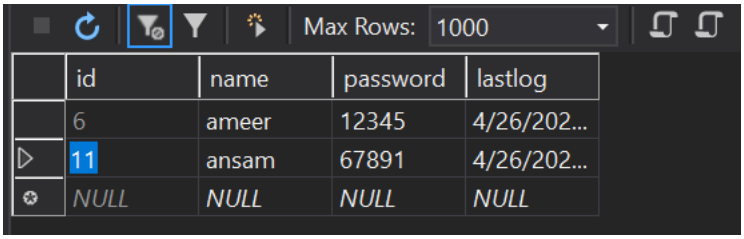

Figure (26): SQL server database table of Admin login in the current study.

2- Account of patient login table .

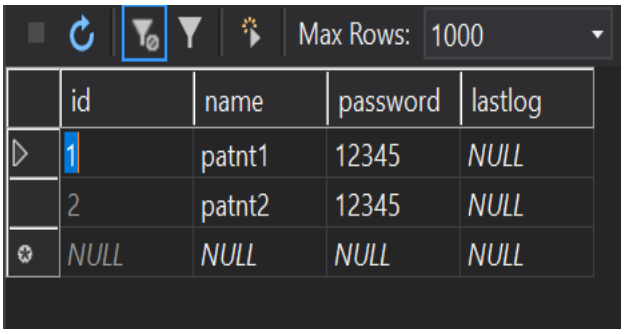

Figure (27) : SQL server database table of patient login in the current study.

3- Report table: it contains on the report information of patient which testes and information registered.

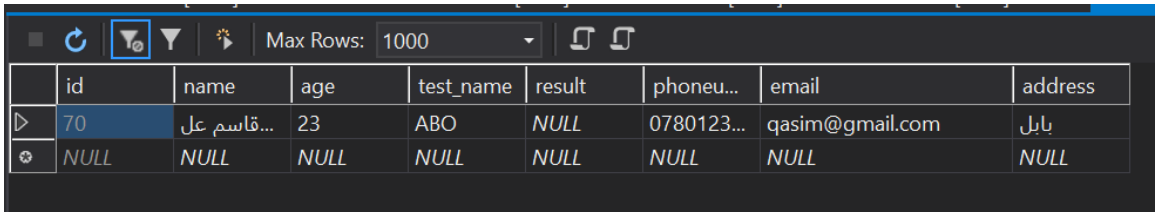

Figure (28) : SQL server database table of report table in the current study.

4- Comment of required test table.

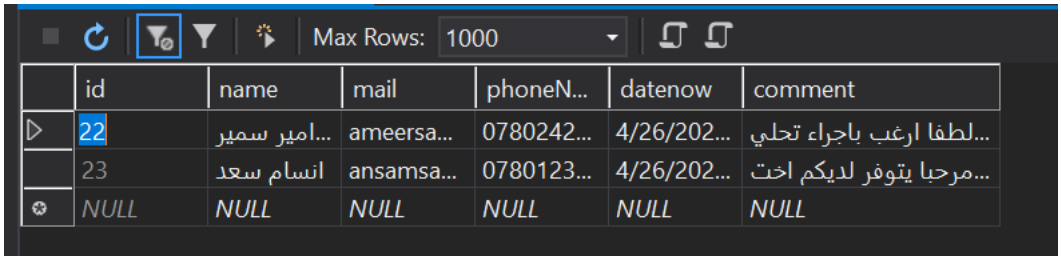

Figure (29): Database Tables in the current study.

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CONCLUSION

The proposed Electronic Blood Analysis Systems can process blood samples quickly, providing results in a fraction of the time compared to traditional methods. It designed to deliver precise and reliable results, minimizing the margin of error inherent in manual analysis techniques. Electronic Blood Analysis Systems often offer comprehensive analysis, providing detailed information about various blood parameters such as complete blood count (CBC), blood chemistry, blood gas analysis and so on. The system reduced the need for manual intervention, thereby decreasing the risk of human error and improving workflow efficiency. This automation also frees up healthcare professionals to focus on other aspects of patient care. The proposed site provides easy-to-use features and a way to communicate between the patient and the laboratory official through the use of a website instead of actually going and exposure to crowds. Future directions are adding other testing experiments related to virus cases, adopting analytical experiments from the results of a blood test to anticipate future diseases and making application on mobile for these purposes.

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Conflict of interests

There are non-conflicts of interest

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الخلاصة

المقدمة:

الدور الرئيسي هو المساعدة في ضبط مستوى الاشتباه السريري للتشخيص للمساعدة في استبعاده أو استبعاده. كما أنها تستخدم لمراقبة الأمراض. في الممارسة العملية مع مستوى الاشتباه السريري واحتمال نتيجة اختبار معينة.

طرق العمل:

الطريقة المقترحة المستخدمة لبناء الموقع هي Visual Studio 2015 مع قاعدة بيانات SQL server لتوفير إمكانية التفاعل والتواصل الإلكتروني بين المريض ومسؤول المختبر، من خلال الحجز المسبق عبر الإنترنت ومن الممكن إنشاء حساب للمريض أيضا ، مما يسمح له بالوصول إلى معلومات حول تحليل الدم داخل المختبر وكذلك القدرة على طباعة التقرير على شكل ورقة تقرير.

الاستنتاجات:

يوفر موقع النظام المقترح إمكانية اختبار الدم لثمانية من طرق فحص الدم الشائعة ، ممثلة في الاختبارات التالية: معرفة فصيلة الدم (ABO) ، عدد خلايا الدم البيضاء (WBC) / عدد خلايا الدم الحمراء ، عدد الصفائح الدموية ، وقت ترسيب كرات الدم الحمراء (ESR) ، تقدير الهيموكلوبان (HB) إلى التجربة السادسة ، تحديد الهيماتوكريت (PVC) ، التجربة السابعة قياس وقت النزيف (BTE). أظهرت النتائج أن قدرة الدراسة الحالية على تقديم تحليل سريع ودقيق ومفصل لعينات الدم دون الحاجة إلى المعالجة اليدوية وتؤدي إلى توفير التكاليف لمرافق الرعاية الصحية على المدى الطويل.

الكلمات المفتاحية:

فحص الدم ; معرفة فصيلة الدم (ABO) ; الويب ; ASP.NET ; التحاليل المختبرية.