

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería de Sistemas e Informática

Tesis

**Web System for the Management of Clinical
Laboratory Test applied to Health Facilities in Rural
Areas**

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Para optar el Título Profesional de
Ingeniero de Sistemas e Informática

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Web system for the management of clinical laboratory test, applied to health facilities in rural areas

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Abstract

When visiting health facilities in the interior of Peru, considered as rural areas, we mostly found many shortcomings in the management of health facilities, which is not allowing efficient management, one of the processes is the registration of clinical and pathological analysis, the information they have are in Excel books or notebooks, which makes it difficult to search for patient and processing reports, stopping the good service in health facilities and delays the patient waiting for their results. In this paper we present the design of a web system for the process of care in the clinical laboratory service in health facilities in rural areas, we present the details of the implementation, the main interfaces and a statistic related to the application.

Keywords

Health center, Web system, medical information, database, application, clinical analysis

1. Introduction

The use of technology in the area of health is playing an important role in the democratization of health, which is why many of the innovations in health are supported by technology, we find work related to the use of brain-computer interfaces, in order to characterize the behavior of the human brain in different situations [1]. The use of technology is related to the use of new communication protocols. If we work with current devices, we must use the latest generation of communication protocols and devices for wireless communication, allowing greater connectivity to take advantage of the benefits of medical equipment [2,3]. These devices are related to state-of-the-art technologies, such as virtual reality and the human-computer interface [4,5].



Technology in healthcare is being used from the design of simulation models for different applications [6]. We also find applications where new technologies such as RFID are applied to ensure medical information and availability [7]. These new technologies are being used in new devices, as well as in mobile devices [8,9]. All of them with the intention of being able to manage medical information in the different health centers and in the services that health centers can provide [10,11].

The works described are related to the use and implementation of technologies in health centers, located mainly in cities, for the case of towns or rural areas, this situation is contrary, showing a need for the use of technology and new equipment, the intention of this research is to propose a solution for the clinical laboratory service, helping in the process of patient registration and reporting of test results, we explain in detail the implementation and an evaluation of its implementation.

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2. Materials and Methods

The materials we present are related to the description of the problem and the description of the implementation of the web system:

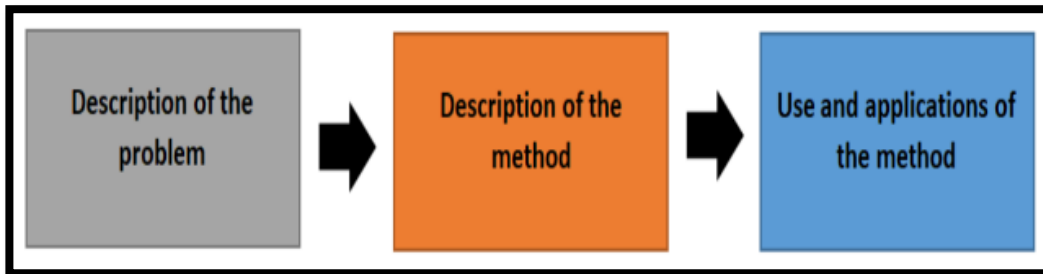


Figure 1: Description of the problem

Figure 1 shows the components corresponding to the materials and methods developed below:

2.1. Description of the problem

Currently there is a gap between health services in rural areas compared to services in cities, this gap makes it possible that many of the services are slow and complicated, one of the basic services is related to the management of laboratory tests, where it is based on the registration in notebook or Excel files. This way of working is very common in rural areas.

The development of a web system for the processes related to the management of a clinical laboratory section, will allow to establish more effective procedures for the registration and search of laboratory tests, where it will be possible to consider the time of registration of patient data, the system will reduce the time of issuance of results and we will achieve an improvement in patient satisfaction with respect to care.

2.2. Description of the method

The following is the description of the method and procedures for the implementation of the system, where a three-layer architecture is considered:

1. Presentation layer: Known as client layer. It refers to the user delivery, that is, it has an interaction with the user through the application interface.
2. Business logic layer: for data validation, dynamic content management and generation of information for the user. In this layer, the customer's request is taken and related to the data layer for data storage.
3. Data layer: this layer contains the data used by the application, that is, data that has to do with how and how the information is stored and how you have to get to it. To communicate with the data, it does so through an API.

This architecture is used by several interested entities around the world through a network. We can mention that the architecture consists of two parts: a client and a server, so you can install two types of applications:

2.2.1. Client Side

We execute the code on the user's machine, the server provides the application and the browser is responsible for executing. For this application model, clients must have a compatible browser and

application specifications, known as script. The client-side languages can be HTML, CSS and JavaScript, among the best known. There are also frameworks that facilitate the development work such as Angular or Bootstrap (Berenguel Gómez, 2015).

Unlike the client side, the server runs the application, forming an HTML code that is returned so that it can be sent to the client through the HTTP protocol. The server executes the script, reducing compatibility issues with client browsers. Some server-side languages include PHP, Java, Python, C#, etc. Server-side scripts are secure, unlike client-side scripts, which are flat files making them vulnerable to attacks.

2.2.2. Backend

Part of the server, responsible for the correct functioning of the logical layer of the application. The application receives, processes and sends the data to be presented to the client.

In the backend we create the connection with the database, apply logical functions and manage the security of the application.

Backend Elements

- Server: it can be Apache, XAMPP, Nginx, IIS, among others.
- Database: some are generally used such as MySQL, SQL Server, Oracle and PostgreSQL.
- Programming language: The backend also uses technologies such as Python, Ruby, NodeJS, Java, .Net, PHP, etc.
- API: Rest or Soap

2.2.3. Frontend

It is on the client side, i.e. the part of the application that has a direct interaction with the user. Web technologies such as HTML, CSS or JavaScript are used to develop the components with which the user will interact and frameworks such as React, Angular, Bootstrap, among others, can be used.

Before the complexity was on the server side (backend), if any change was required in the web page needed to be reloaded to the same, however, came AJAX (Asynchronous JavaScript and XML). This technology is a set of techniques that allows you to create asynchronous applications, which means that you can receive or send information to the server without reloading the page, since these processes are performed in the background.

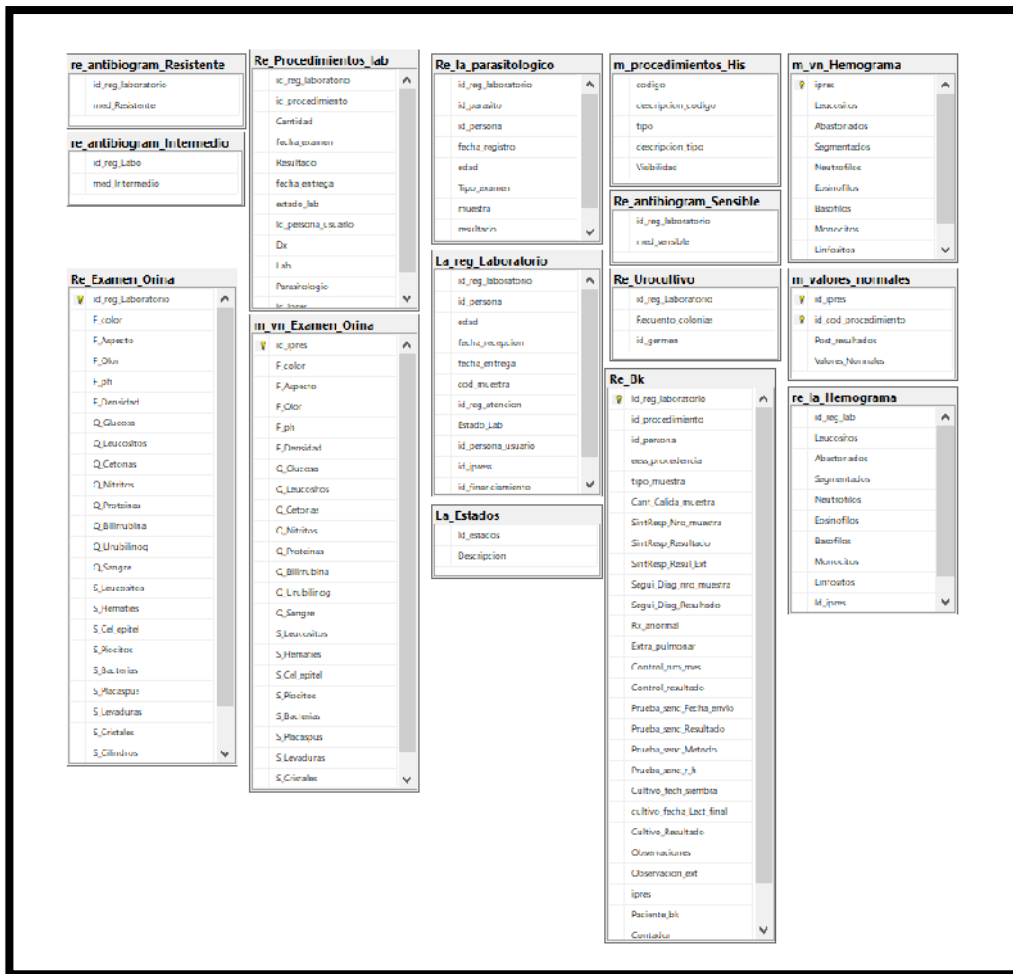


Figure 2: Diagram of the database model

In Figure 2, we present the diagram of the implemented database, where we have the tables of type of examination, such as urine, urocultivo, blood, complete hemoglobin, hemogram, parasitology.

| Nombre | Fecha de modificación | Tipo | Tamaño |
|------------------|-----------------------|----------------------|------------|
| DBProlab.mdf | 11/12/2022 20:56 | SQL Server Databa... | 73,728 KB |
| DBProlab_log.ldf | 11/12/2022 20:56 | SQL Server Databa... | 73,728 KB |
| DBProlab.mdf | 4/12/2022 19:29 | SQL Server Databa... | 663,552 KB |
| DBProlab_log.ldf | 4/12/2022 19:29 | SQL Server Databa... | 688,384 KB |

Figure 3: Files corresponding to the database

In Figure 3, we present the detail of the files needed to run the database, it is necessary for the development, to know how the database is structured and the files needed for its correct operation.

| Nombre | Fecha de modificación | Tipo | Tamaño |
|-------------------------|-----------------------|-----------------------|----------|
| Admision.exe | 6/11/2022 17:17 | Aplicación | 2,636 KB |
| Admision.exe.config | 14/06/2022 17:13 | XML Configuratio... | 1 KB |
| Admision.pdb | 6/11/2022 17:17 | Program Debug D... | 424 KB |
| BouncyCastle.Crypto.dll | 8/12/2020 13:05 | Extensión de la ap... | 2,548 KB |
| Common.dll | 10/10/2022 09:02 | Extensión de la ap... | 7 KB |
| Common.dll.config | 4/06/2022 17:02 | XML Configuratio... | 1 KB |
| Common.pdb | 10/10/2022 09:02 | Program Debug D... | 28 KB |
| DataAccess.dll | 10/10/2022 21:38 | Extensión de la ap... | 78 KB |
| DataAccess.dll.config | 4/06/2022 17:02 | XML Configuratio... | 1 KB |
| DataAccess.pdb | 10/10/2022 21:38 | Program Debug D... | 132 KB |

Figure 4: Main form files

Figure 4 shows the main files of the System, for the execution of the Web System, where the System starts with the execution of the file "Admision.exe". Next, we present the interfaces developed for the functionalities of the System:

- Administrator user login

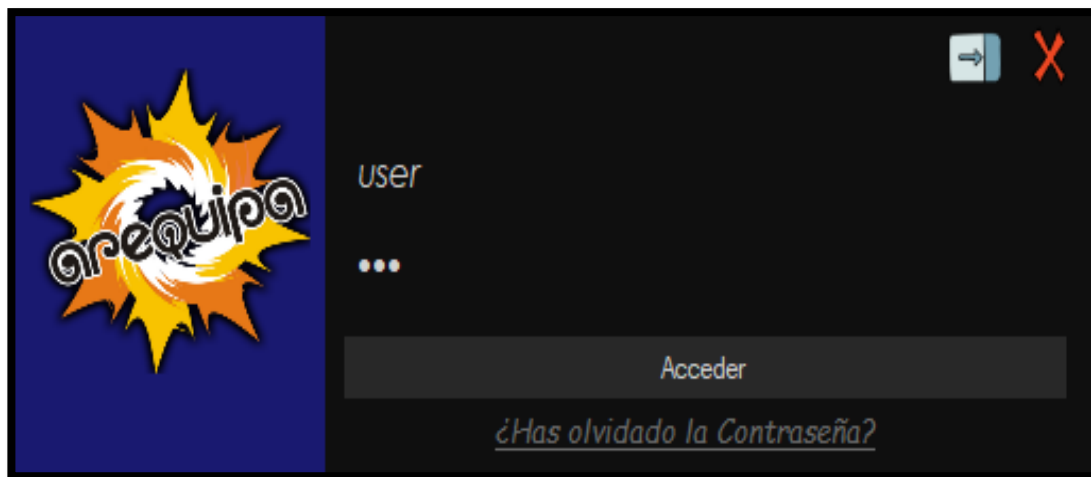


Figure 5: User login screen

Figure 5 shows the validation of the user who will use the system. Each user, who is a health center worker, must be registered in the system and have a user name and password.

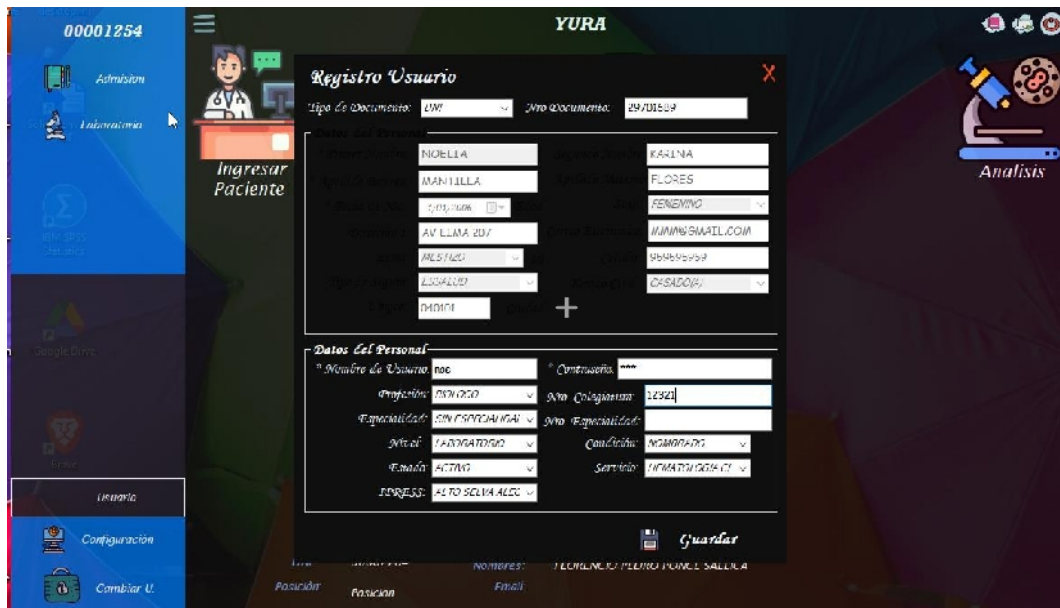


Figure 6: User registration screen

Figure 6 shows the interface for the registration of new users, where the profession, position, health center, address and, most importantly, an 8-digit password must be entered.

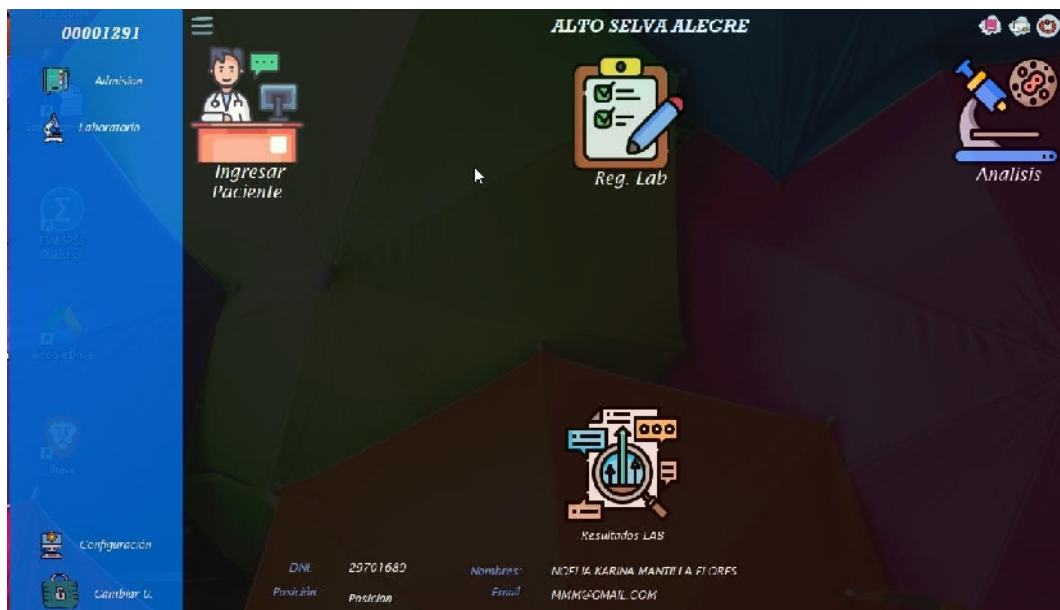


Figure 7: System main menu

Figure 7 shows the main menu interface, where we have the processes of patient entry, laboratory test registration, analysis registration and results reporting.



Figure 8: New patient registration

Figure 8 shows the patient registration interface, where it is necessary to present the national identity document.

 A screenshot of a 'Registro Paciente' (Patient Registration) form. The form is titled 'prueba Registro Paciente' and contains numerous input fields for personal data. Fields include: 'Tipo de Documento' (dropdown), 'Nro Documento' (text), '* Primer Nombre' (text), '* Segundo Nombre' (text), '* Apellido Paterno' (text), '* Apellido Materno' (text), '* Fecha de Nacimiento' (date picker showing 10/10/2022), 'Edad' (text), 'Ubigeo' (text), 'Ciudad' (text with a plus sign), 'Doc. del Padre' (text), 'Doc. de la Madre' (text), 'Dirección 1' (text), 'Dirección 2' (text), 'Localidad' (text), 'Correo Electrónico' (text), 'Telefono' (text), 'Celular' (text), 'Etnia' (dropdown), 'Sexo' (dropdown), 'Grupo Sanguíneo' (dropdown), 'Estado Civil' (dropdown), 'Ocupación' (dropdown), 'Disponibilidad' (dropdown), 'Estatus' (dropdown), 'Tipo de Seguro' (dropdown), 'Codigo de Assegurado' (text), 'Historia Clínica' (text), and 'Historia Familiar' (text). There is also a large 'Observaciones' (Observations) text area at the bottom. A 'Guardar' (Save) button is located at the bottom right.

Figure 9: Registration of new patients

Figure 9 shows the registration of new patients, where the main personal data are recorded. After having registered the data, the next procedure is to register the samples for clinical analysis, as shown in the following figure:

Registro de Toma de Muestra Laboratorio

Documento de Identidad: C

Apellidos y Nombres:

Dirección 1:

* Fecha de Nacimiento: 10/10/2022 Edad

Teléfono:

Código de Muestra:

Procedimiento Laboratorio

- Bateria Gestante
- Púrpura
- Recien Nacido
- Cred
- IDC
- Dants
- Hemostasia
- Hematología
- Bioquímica
- Parasitología
- Inmunología
- Uroanalisis
- Toma de Muestra
- Serología
- BK
- COVID-19

Procedimiento Laboratorio

- Examen Completo de Orina
- Bioquímica
- Hematología
- Urocultivo / Antibiograma
- Serologicos
- Otro
- Parasitologico
- Secreción

| codigo | descripcion_codigo | Cantidad |
|--------|--------------------|----------|
| | | |

Bioquímica:

- Glucosa Pré-prandial
- Glucosa Post-prandial
- Acido Urico
- TGO
- TGP
- Bilirrubina T
- Bilirrubina D
- Bilirrubina I
- Creatinina
- Colesterol T.
- Triglicéidos
- HDL Colesterol
- LDL Colesterol

Parasitológico:

- Directo
- Concentrado
- Seriado
- Test de Graham

Serología:

- VIH
- VDRL
- Test Latex
- RPR
- Reacción de Widal
- Pregnisticon

Secreción:

- Gram
- Directo

Hematología:

- Hemoglobina
- Hematocrito
- V.S.G
- T. Coagulación
- T. Sangría
- Fcto. Hematias
- Grup. Sanguíneo / Factor RH
- Hemograma

Figure 10: Registration of samples for laboratory

Figure 10 shows the registration of a clinical laboratory examination, where the personal data and the laboratory procedures to be analyzed, which are the different types of examinations, are registered.

0001298

15 DE AGOSTO

Resultados de Laboratorio

Fecha: 5/12/2022 Hora:

Resultados del Día

| Numero de Orden | Nombre de Paciente | Edad | Fecha de Examen |
|-----------------|-------------------------|------|-----------------|
| 29854045 | VALLE FERRANUCHE TORRES | 77 | 6/12/2022 |

Documento de Identidad: 00001574

Nombre: NOE MAR HA

Posición: Posición

Figure 11: Laboratory results report

Figure 11 shows the results of the report of the tests performed, after having finished the clinical analysis process, the search is performed by searching by patients, organizing the results according to the dates of the tests performed.

Reporte Parasitologico Mca: []

Nro de Muestras: [] Nro de Pacientes: [] Nro de Positivos: [] Nro de Negativos: [] **Generar Reporte**

Agentes

Total de Agentes: []

Grupo / Parasito

PROTOZOARIO Nº []

HELMINTOS Nº []

PROTISTAMIN Nº []

Total Nº Positivos []

MONOPARASITISMO []

BIPARASITISMO []

TRIPARASITISMO []

TETRAPARASITISMO []

PENTAPARASITISMO []

HEXAPARASITISMO []

HEPTAPARASITISMO []

OCTAPARASITISMO []

Total de Agentes: []

Por Grupo (Base Positiva)

0,1-1 Años []

1,1-5 Años []

5,1-10 Años []

10,1-15 Años []

15,1-20 Años []

20,1-25 Años []

25,1-30 Años []

30,1-35 Años []

35,1-40 Años []

40,1-45 Años []

45,1-50 Años []

50,1-55 Años []

55,1-60 Años []

60,1 > Años []

T. Positivos []

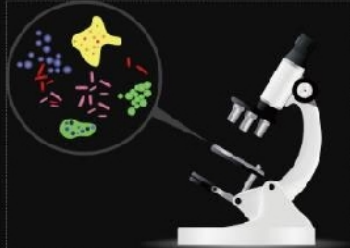


Figure 12: Laboratory test report

Figure 12 shows how the laboratory results are presented, depending on the type of examination, a different form will be used.

**CENTRO DE SALUD
15 DE AGOSTO**

REPORTE PARASITOLOGICO

Años: 2022 PERIODO: Diciembre MICKUREU: MICHUNEN LAB: 15 DE AGOSTO

N° MUESTRAS: 7 N° PACIENTES: 1 N° POSITIVOS: 1-100% N° NEGATIVOS: 0-0%

| AGENTES | | GRUPO/PARASITO | |
|-----------------------------|---|-------------------------------------|--------|
| <i>E. coli</i> | 1 | PROTOZOARIOS Nº | 1 100% |
| <i>E. histolytica</i> | 1 | HELMINTOS Nº | 0 0% |
| <i>B. hominis</i> | 0 | PROTISTAMIN Nº | 0 0% |
| <i>Shigella flexneri</i> | 0 | TOTAL Nº POSITIVOS | 1 100% |
| <i>Giardia lamblia</i> | 0 | TIPO PARASITO | |
| <i>Trichomonas hominis</i> | 0 | MONOPARASITISMO | 0 |
| <i>Cryptosporidium sp.</i> | 0 | BIPARASITISMO | 1 |
| <i>Cyclospora</i> | 0 | TRIPARASITISMO | 0 |
| <i>Isospora belli</i> | 0 | TETRAPARASITISMO | 0 |
| <i>Ch. mesnili</i> | 0 | PENTAPARASITISMO | 0 |
| <i>Citronorchis sp.</i> | 0 | HEXAPARASITISMO | 0 |
| <i>Paragonimus sp.</i> | 0 | HEPTAPARASITISMO | 0 |
| <i>Fasciola hepatica</i> | 0 | OCTAPARASITISMO | 0 |
| <i>T. solium</i> | 0 | TOTAL AGENTES | 2 |
| <i>T. saginata</i> | 0 | POR GRUPO ETAREO (POSITIVOS) | |
| <i>Taenia sp.</i> | 0 | 0,1-1 AÑOS | 0 |
| <i>D. pacificum</i> | 0 | 1,1-5 AÑOS | 0 |
| <i>H. nana/H. diminuta</i> | 0 | 5,1-10 AÑOS | 0 |
| <i>D. caninum</i> | 0 | 10,1-15 AÑOS | 0 |
| <i>Ancylostoma nec</i> | 0 | 15,1-20 AÑOS | 0 |
| <i>A. duodenale</i> | 0 | 20,1-25 AÑOS | 0 |
| <i>Necator americanus</i> | 0 | 25,1-30 AÑOS | 0 |
| <i>Ascaris lumbricoides</i> | 0 | 30,1-35 AÑOS | 0 |
| <i>S. stercoraris</i> | 0 | 35,1-40 AÑOS | 0 |
| <i>T. trichiura</i> | 0 | 40,1-45 AÑOS | 0 |
| <i>L. vermicularis</i> | 0 | 45,1-50 AÑOS | 0 |
| <i>Capillaria sp.</i> | 0 | 50,1-55 AÑOS | 0 |
| <i>Trichostrongylus sp.</i> | 0 | 55,1-60 AÑOS | 0 |
| <i>Rhabditis sp.</i> | 0 | 60,1 > AÑOS | 1 |
| <i>Meloidogyne sp.</i> | 0 | TOTAL Nº POSITIVOS | 1 |
| <i>Encyrtus nana</i> | 0 | | |
| <i>Iodamoeba butschlii</i> | 0 | | |

**CENTRO DE SALUD
15 DE AGOSTO
EXAMEN DE LABORATORIO**

DATOS DEL PACIENTE

NOMBRES Y APELLIDOS: IVAN ALEX MANRIQUE TORRES **DNI:** 29894535
EDAD: 72 AÑOS **SEXO:** FEMENINO
FECHA DE RECEPCIÓN: 8/12/2022 00:00:00
FECHA DE ENTREGA: 8/12/2022 00:00:00

EXAMEN(ES):

| Cant. | Codigo | Descripcion | Resultados |
|-------|--------|--------------------------------|------------|
| 1 | 82585 | DOSAJE DE CREATININA EN SANGRE | 1000-100 |
| 1 | 85018 | DOSAJE DE HEMOGLOBINA | 10-15 |

Realizado por:
NOE KAR MANT FLO

Figure 13: Clinical laboratory examination report

Figure 13 shows how the system reports the tests performed in a PDF format so that they can be evaluated by the physician.

3. Results

This work was carried out based on the problem of the process that is performed in health facilities in rural areas, applied to the Peruvian reality, health centers located in rural areas, mostly do not have computer systems for the management of health processes, one of the important processes in medical diagnosis, is related to clinical laboratory tests, The implementation of the proposal is important because it allows the automation of clinical processes in health centers in rural areas, which allows the registration of patient data and the issuance of patient results, we can keep track of tests performed, to keep track of the tests performed, as well as the waiting time to perform the registration and the time to view the results.

As a mechanism for evaluating the level of impact generated by the proposal, we performed a descriptive analysis with different indicators, as described below:

Indicator: number of Laboratory examinations with no result due to technical error, evaluated before and after the implementation of the proposal.

Table 1: Descriptive analysis of the indicator number of laboratory test with no result due to technical error

| Tests | Prior to the implementation of the proposal | After implementation of the proposal |
|---------------------|---|--------------------------------------|
| Number of tests | 100 | |
| Test without result | 18 | 0 |

In Table 1, we can see that, from a sample of 100 tests analyzed in the same period of time, before the implementation of the proposal, there was an average of 18 tests without results due to the effect of the work done on sheets and written by the same health personnel, with the use of the proposal there are 100% of tests with results, due to the use of the system, working on the premise that all tests recorded have results.

4. Conclusion

The conclusions we reached at the end of this research, is related to the development and implementation of computer systems, dedicated to improving the management processes of health processes, in our case applied to health centers in rural areas, it is evident that with the use of the proposal will improve the care of laboratory tests, resulting in improved management of human resources, equipment, supplies and laboratory materials, which can improve the degree of satisfaction by the users of health services that are patients in rural areas.

The implementation of new health services management processes allows for the streamlining of procedures in health facilities in rural areas, as well as the connection with reference centers in the regions, thus integrating them into the National Health System, all of this to achieve user satisfaction with health services. In relation to the development of the proposal, it allows to expand its scope by implementing the visualization of laboratory tests over time, as well as to have the results of all tests performed.

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