Journal of Theoretical and Applied Information Technology
15th March 2022. Vol.100. No 5
2022 Little Lion Scientific
ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

AN ENHANCED PATIENT E-REFERRAL MODEL FOR A THREE-TIER HEALTH CARE SYSTEM.

[1]ETIM, OKORI DAVID, [2]EDIM, AZOM EMMANUEL, [3]ANA, PRINCE ONEBIENI, [4]EMMANUEL U. OYO-ITA, [5]INYANG, GABRIEL AKIBI, [6]ETIM, ESU OYO-ITA

[13456]Department of Computer Science, Cross River University of Technology, Calabar, Cross River State, Nigeria.
[2]Department of Computer Science, University of Calabar, Calabar, Nigeria.

E-mail: [1]etimodave@gmail.com, [2]edimemma@gmail.com , [3]anaprince@yahoo.com, [4]emmanueloyoita@crutech.edu.ng, [5]gain140270@gmail.com, [6]etimoyo-ita@crutech.edu.ng

ABSTRACT

The patient referral system used in health care in Nigeria is paper based. The referral system lacks a defined structure for presenting information to enhance efficiency and timely service. Existing e-referral models have been implemented in two-tier health care systems and are not suitable for three-tier health care system in Nigeria. This study was carried out to develop an e-Referral model for a three-tier health care in order to provide a well define structure and language of presentation in each tier and enhance communication and cooperation among the three tiers of care providers. Ethical approvals were obtained for the participation of care providers during data collection. The data was used to design an e-referral model and implemented a web based application. A usability test was conducted with participants from the three tiers of health facilities. The results showed that participants scored 71.2, 75 and 80.7 for primary, secondary and tertiary health care participants, which is above standard usability score. Further results obtained after a period of six months from users who have been using the e-referral within the three tiers health care providers showed a decrease in error rate from 51.4% to 18%, which is an improvement in interactions accuracy and handling of referral cases in the health care centers.

Keywords: *Patient E-Referral model, Three-tier Health Care Delivery, Primary Health Care, Secondary Health Care, Tertiary Health Care.*

1. INTRODUCTION

Patient referral process is a critical component of health care delivery and the effective management of referral information is necessary for a successful care giving process.

However, communication problems such as difficulty of transmitting adequate information to the provider at the next tier, lack of feedback mechanism, difficulty to understand the information, poor tracking mechanism and easy misplacement as well as lack of integration and synergy of the various levels of health care delivery, were some of the identified problems of manual (paper) patient referral process, which hinder efficient and timely delivery of health care services. These challenges have necessitated the use of information technology in this study, for handling patient referral information in order to improve the patient referral process and ameliorate most of the inconsistencies existing in the process.

According to [1], this ICT innovation has been successfully implemented by some hospitals with reports of remarkable improvement in patient access to specialist care, improvement on primary-specialist interaction, reduction of inappropriate referrals, reduction in wait times, and collaboration among the health care providers.

In Nigeria and in some countries in Africa, the Primary Health Care (PHC) level is the "first contact" facility for patients especially in rural communities. Though this level of health care has received much support from the government, World Health Organisation (WHO) and other non-governmental organisations (NGOs), the primary health care facilities in Nigeria still lack the capacity to handle most health care challenges, due to poor facilities and lack of adequate personnel. This has resulted in some patients avoiding (bypassing) the primary health care facilities and moving straight to secondary or tertiary health care facilities.

The e-Referral system is an innovative intervention that use the agility provided by ICT infrastructure in order to improve the referral flow

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

among the health care providers. The health care system in Nigeria is structured in such a way that it is expected that the patient first point of contact is the primary health care facility, after which the patient moves to the secondary health care facility and if the problem still persist, the patient is referred to the tertiary facility.

Studies shows that most e-Referral implementations are primary – specially care models, this is as a result of the advancement in the health care system. In Nigeria and sub-Saharan Africa, health care systems are still underdeveloped in terms of manpower and physical infrastructure. Not much has been done to improve the intercommunication that is necessary among the **primary-secondary-tertiary** providers, where a three-tier health care delivery system is involve and the paper based method of referral is still in use. The primary centres with community health care workers are the closest to the larger population that lives in rural areas and suburban centres, but lack well trained health professionals. Well trained medical professionals do not like to work and live in rural or suburban areas. The community health worker's role or duties in health care delivery are restricted to some basic functions, in line with the health care policy in Nigeria and the level of professional qualification. And for the secondary health care level, general practitioners and few health care specialists may be found. The larger number of specialists are found in the tertiary care facilities in cities. Implementation of a three-tier e-referral system will enhance intercommunication, case management and efficient health care delivery.

Paper based referrals so far do not have a definite structure which create difficulty in understanding. Documentation of the paper referrals are based on the experience of the referring care giver. E-referral will provide a definite structure, improve understanding and intercommunication among the three level health care system. There is need to improve, as patients would actually need to traverse the three levels of health care, in countries with less developed health systems. Hence the need for an alternative, usable and efficient e-Referral system for the three levels of health care delivery found in most developing countries. This research was carried out to implement an electronic referral system to facilitate the transmission of referral information in a three-tier health care delivery structure, in order to reduce, if not to eliminate the difficulties and problems being encountered currently in the health care system.

In countries with less developed health care delivery system, verbal referrals are rampant among most primary care providers (PCPs) and some secondary care providers (SCPs). Also, paper based referrals are mostly used to refer patients from one level of health care delivery to another. E-referrals systems are yet to be adopted and implemented in most of these health care facilities as is the case in Nigeria. This is largely due the lack of ICT infrastructure such as computer hardware, software, networking facilities and electronic health records in the health care centres. Adequate strategies and policies have also not been put in place to encourage ICT implementation in the health care delivery system.

The paper referral system in Calabar and its nearby communities is laden with various challenges as revealed by the health care workers during the study. These include loss in transit, difficulty on patients knowing who to direct the referral to, lack of adequate feedbacks. Sometimes verbal referrals were common due to insecurity/difficult situations. Paper documentation was time consuming, while poor documentation led to difficulty in understanding. Man-made and natural disasters led to loss of paper referrals making it difficult for smooth case management. The storage and retrieval of patient referral information was cumbersome. As a result of these challenges, there is poor access to specialists' care, the referral process is poorly coordinated, and there exist inter-communication gap among the health care levels. This study looks at how to improve the referral process amongst the three tier health care providers in Calabar and its nearby communities by developing an easy to learn and use e-Referral system, to address the challenges affecting the paper based referral method, as well as put in place an e-Referral model that is adapted to the peculiarities of the existing health delivery system and challenges within the study area.

Three primary health centres, one secondary and one tertiary centres were involved in the study. The study was only limited to public health establishments within the study area.

The paper based referral process within the three tier health care system is posing a lot of challenges that hinder successful operation of referral in health care delivery such as delay, lack of uniform structure and difficulty in transmitting the right information for proper understanding. Also, most existing e-referral structures are operated in two-tier health care delivery systems,

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

where the health care systems are well developed and can accommodate the two-tier structure and are able to address their health care needs. This study is carried out in a resource constraint health care environment where the three tier health care system is practiced. The peculiarities and settings in the three-tier system not only impose some constraints in health care delivery that are very different from the primary-secondary health care delivery models. These include regulations and policies, education, manpower, facilities and communication barriers. The existing paper based method is complex to manage, hence the need for the enhanced three tier e-referral model.

Research activities have been carried out concerning patient e-Referral systems in health care delivery around the world with great successes. Most of these e-referrals are customized and tailored to the health care system operated in such places or countries.

[2] discussed a Primary–Specialty model, an e-Referral innovation that was found to enhance health care delivery process. The model indicated considerable improvements in specialty visits and access to specialty care by patients. The specialist reviewers indicated their satisfaction about the enhanced level of interaction, provision of education for the participating PCPs and the co-management as well as reason for referral and clinical question.

2. LITERATURE REVIW

[3] developed an XML based system that enhanced the sharing of patient care data over the Internet. The XML approach facilitated sharing of information by allowing medical records to be associated with xml tags, making it easy for the computer to derive the meaning and structure of the document over the internet.

According to [1], irrespective of the health care delivery model adopted to increase access and improve primary health care delivery, patients may still require specialty attention, which has made it expedient to introduce new innovations to improve referral services. Consequently, a study was carried out in three communities of San Francisco, Los Angeles and Connecticut, and the interaction and collaboration that emanated among the providers enhanced access to specialty care for the patients and reduced in-person specialist visits as well as reduction in wait time for appointment with the specialists.

In most developed countries like UK, Primary care Physician provide health care and act as **gate keepers** to decide who require secondary or specialist care [4]. The Zambia Electronic Perinatal Record System (ZEPRS), known to be the first electronic perinatal patient referral system in sub-Saharan Africa, is another specialty based application [5]. It was developed for perinatal patient referral system and enabled users to enter patient data in real time.

The clinical effectiveness and cost benefits of the e-Referral system has been studied and evaluated by some researchers and it was found that using the e-referral lowered health care delivery cost, yielded clinical and economic benefits as discussed in a study conducted by [6].

The study by [7] stated that poor communication among care providers can result to unnecessary costly referral on both the provider and the patient. In their model, a patient treated at higher care (specialty) level is returned back to the referring, smaller original hospital, for continuity of care. This approach was found to yield improvement in the use of resources of specialist hospitals, allowing patients to have efficient professional assessment, avoid unjustified transfer, shorten problem resolution times and was less costly.

[8] presented a two-level e-Referral model which was used to improve the out-patient primary - specialist care interface. The e-Referral model showed time and cost savings in some specialties. [9] evaluated the impact of 2-way communication (primary-specialist) iterative novel e-Referral system in rheumatology in safety-net health system. The result of the study showed that between 2008 and 2012, out of 2383 cases reviewed on e-Referral systems, 2105 were analyzed and one-fourth were resolved without the patients needing a clinic visit. Their approach was also found to have facilitated communication between referring clinicians and the rheumatologists.

The e-referral model in this study is an attempt to eliminate loss of referral documents in transit as evident within the health care system, enhance the referral process and management through speedy storage and retrieval of referral information, facilitate case management through proper inter-communication among the various health care providers. It will also eliminate illegibility in referrals documents. This study emphasizes the three-tier approach to electronic referral as against the two – tier (primary – specialty) approach

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

already in existence in most developed health care systems of the world.

The apparent difference in health care delivery policies and systems in different countries makes it difficult to apply the same electronic referral approach. For instance, in the UK and other developed countries, the primary health care level has facilities and manpower to cater for a patient adequately before the patient is referred to the specialist, as compared to the primary care centres considered in this study. The primary-specialty model had shown tremendous success in improving health care delivery in regions that have implemented it. However, in Nigeria, the existing health policy and structure differ from the two-tier model. The two-tier model if implemented in this case, will increase pressure on the existing secondary and tertiary health care facilities. It will increase cost and reduce access to health care to the larger population in the rural and suburban areas. Hence, the need for an e-referral system that reflects the policies and structure of the health care system in Calabar and its environs. As the patient is referred from one level of health care delivery to the next, it is necessary to maintain accurate and timely referral information regarding the patient and to have effective interaction among the providers or care givers.

Electronic referrals have been implemented [8],[9], but their structure is based on a two tier health care delivery structure (primary-tertiary or primary–specialist models). These suit the peculiarities and regulations within these environments. In a three tier health care system with its peculiarities, regulations and policies, implementation of two tier structure will not meet the needs of the health care system. The regulations and policies governing the operations of the three tier consisting of the primary, secondary and tertiary are different, hence the need for a three tier e-referral structure. In this health care model where the primary health care centres are at the base, secondary health care delivery (General hospitals or municipal hospitals) at the middle and tertiary health care delivery (specialist hospitals or tertiary hospitals) at the top or highest level. The enhanced patient electronic referral model was designed to meet up with this structure, regulations and policies governing its operation and to enhance health care delivery.

3.0 RESEARCH METHOD

3.1 Ethical Issues

Prior to interacting with health care personnel in the selected health care facilities, the study sought ethical consent (Appendix A) from the Ministry of Health and University of Calabar Teaching Hospital, Calabar. An application and proposal for the study was submitted to the respective ethical committees for consideration. The proposal was defended and amendments were made and the application was approved in the two institutions, thereby commencing the research. Interaction with various categories of participants was done in a way to avoid interference in the discharge of their duties and job schedules. Participation in the research was voluntary at each tier of health care delivery.

3.2 Data Collection

Four data collection methods were employed in this study namely: stakeholders' interactions during visits to designated health facilities, questionnaires, interviews and examination of existing documents.

3.2.1 Interviews: Narrative interviews of 5 minutes per session were used. At the Ekpo Abasi PHC, the Head of the primary health care centre and two community health workers were interviewed, to understand how the existing referral process is carried out and to establish the inconsistencies or otherwise of the paper based system. The responses were noted in writing and recorded using a smart phone. This activity was replicated in two other PHC centres (Anantigha and Ikot Ishie).

Interviews were also conducted at the General Hospital, Mary Slessor Road, Calabar, which provides secondary care to the people within and outside Calabar. Here, three nurses and two doctors were interviewed about the referral process, the problems and the expectations for an e-referral system in the hospital.

The University of Calabar Teaching Hospital (UCTH), was the tertiary health care provider chosen for the study. Here, two Doctors, three nurse practitioners and one patient record management staff were interviewed. At this level, the study tried to find out why some patients come directly to the health facility, the difficulties encountered when a patient is referred to this facility, the appropriateness of referral from lower levels of health care and the flexibility or otherwise of referral flow between the health care providers.

3.2.2 Questionnaires: Two different sets (pre-system development and post evaluation) of structured questionnaires were administered in the selected health care centres. The pre-questionnaires were administered to address the issues identified in the design phase of the e-Referral system. The questionnaire on the first part contains yes or no questions and the second part contains a five points Likert scale questionnaire. The Likert scale format used: 1point for "strongly disagree", 2 points for "disagree", three points for "not sure", 4 points for "agree" and 5 points for "strongly agree". The questionnaire helped to provide information among others on:

(i) the problems with paper based referral system.
(ii) the movement or flow of referrals from: PCP to SCP, SCP to TCP or PCP to TCP.
(iii) the communication issues that exist between the providers.
(iv) the level of satisfaction for both patients and providers.

Criteria for eligibility were based on only health staffs who participate in referral activities in their respective health care centres.

3.2.3 Document analysis: In each health care delivery level, the referral documents were requested and examined in order to understand the operations of the referral process. This also helped to confirm the responses obtained from the health workers. The necessary data were extracted to help in design of the e-Referral system. Secondary sources such as Internet, library materials and personal interactions were used extensively to acquire data and information.

The system was evaluated by allowing participants representing each level of health care delivery to carryout basic operations, using three computers (clients) linked to a server system.

Two sessions were involved in the evaluation process; in the primary – secondary session, which involves operations such as category logins, sending e-referral request, viewing the e-referral requests, sending and viewing messages. At the secondary health care level, a nurse practitioner used the platform to view requests and feedback forwarded from the primary level. The primary level participant also sent messages to the secondary level participant. Again, one staff was assigned the role of admin user at each of these levels to perform admin functions.

During the secondary - tertiary session, a nurse practitioner used the platform to create an e-referral document. The process enabled the study to scrutinize and determine if the activity was easy to perform and if the document created, effectively conveyed the required information on the other side. The referral request and messages were then sent to tertiary and nurses at the tertiary level used the platform to view requests and messages from secondary level. The participants at secondary and tertiary levels also responded to the interactions using the platform. The post-evaluation questionnaires were distributed to the three tiers of health care delivery to evaluate the usability of the e-Referral system.

3.3 Sample Population

In considering the study population, the health care delivery pyramid was taken into consideration in terms of man power and health care infrastructure distribution. Many PHC centres are dispersed in the rural communities and suburbs, making it bottom heavy, with disproportionate rate in quality of care as you move up the pyramid. At the middle level of the pyramid, there is drastic decrease in number of health care facilities, with reasonable improvement in health facilities, personnel and services rendered compared to the primary level. At the top, the facilities are fewer in number and are scattered around the country with some states (regions) having one or none. Here, specialist services and high quality of equipment and professionals are found.

The purposive sampling technique was used in the selection of participants, which according to [10], refers to the selection of units or elements that are most useful or representative to the research.

3.3.1 Sample size

The sample size was estimated base on a proportion. This approach was preferred, since estimating the sample size based on a mean will require knowing the population standard deviation (from prior research or other sources). According to [11], when the proportion of the population (p) is not known (either from prior research or other sources), p can be taken to be equal to 0.5(p=0.5), which assumes maximum heterogeneity (i.e. 50/50 split). The sample size based on the sample population required to estimate a proportion with an approximate level of confidence of 90 percent, is determined using the formula as shown in Eq. (1) below:

$$n_r = \frac{4pq}{d^2} \quad (1)$$

Where,

n_r = required sample size

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

p = proportion of the population having the characteristics

q = 1-p

d = the degree of precision

The degree of precision (d) is the margin of error that is acceptable. The constant (4) approximate the conventional multiplier (1.96) ² when alpha (error type I is taken to be 0.05). Since this is an initial study, an error margin (d) of 0.1 was used. The computation is shown in Eq. (2) below:

$$n_f = \frac{4pq}{d^2} = \frac{4 \times 0.5 \times 0.5}{(0.1)^2} = \frac{1}{0.01} = 100 \quad (2)$$

This sample size of 100 was subdivided into three, for the three levels of health care delivery using the ratio 2:1:1, hence, the sample size for the respective health care levels were taken as:

- Primary health care level n_p= 49 (Ekpo Abasi PHC, PHC Ikot Ishie, PHC Anantigha)
- Secondary health care level n_s = 26 (General Hospital Calabar)
- Tertiary health care level n_t = 25 (University of Calabar Teaching Hospital, Calabar)

The collected data were collated and analysed using the measure of central tendency, simple percentages, pie and bar charts analysis were employed to depict the needed information from the data analysis. The interpretations of data for each level were done independently, but the interrelationships between them were highlighted where necessary. We also monitored the usage of the e-referral system with users across selected health care centers within the three tier levels for a period of six months and collected data in order to determine the impact of the e-referral application.

3.4 System Design and Testing

The development of the e-Referral system prototype involved the use of reusable components such as .NET framework, ASP.NET development environment and other web development tools. The e-referral system architectural framework is presented in Figure1.

The design (Figure 1) shows the end-user/presentation layer at the top (user interactions), the business layer (processing activities) and the data services layer, where database functions were implemented.

Data layer is the SQL relational database server embedded in the ASP.NET platform. This takes care of data manipulations, which involves responding to queries and management of the stored data. The user/presentation layer enabled the user to interact with the platform and perform input/output activities. The business logic layer takes care of the back end processing activities, login verifications, execute the application logic and other file operations like updating, deleting, retrieving and storing.

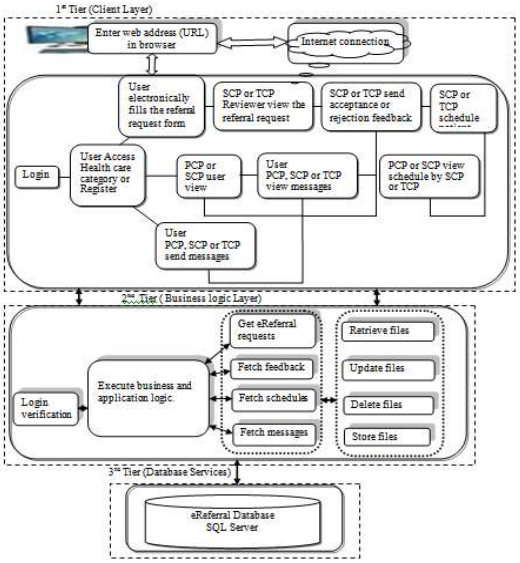


Figure 1: The E-Referral Architectural Framework

3.4.1 The e-referral context based form

The three-tier nature of the referral process for a three-tier health care delivery made it necessary for the electronic referral request form to be filled base on the participant's category.

The electronic referral request form (ERRF) is depicted in Figure 2, it is partitioned into four sections namely; the patient data, clinical data, provider data and other information. The patient data section captures the patient bio-data. The clinical data section captures the patient current medication information; medical history (e.g. diabetic, hypertensive); routine diagnostic tests (RDT); this captures diagnostic tests performed so far on the patient e.g. Blood tests, Stool examination, Urine test (urinalysis), radiology/medical imaging information and vital signs. The provider details section captures the provider details, referring and referred facilities details.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

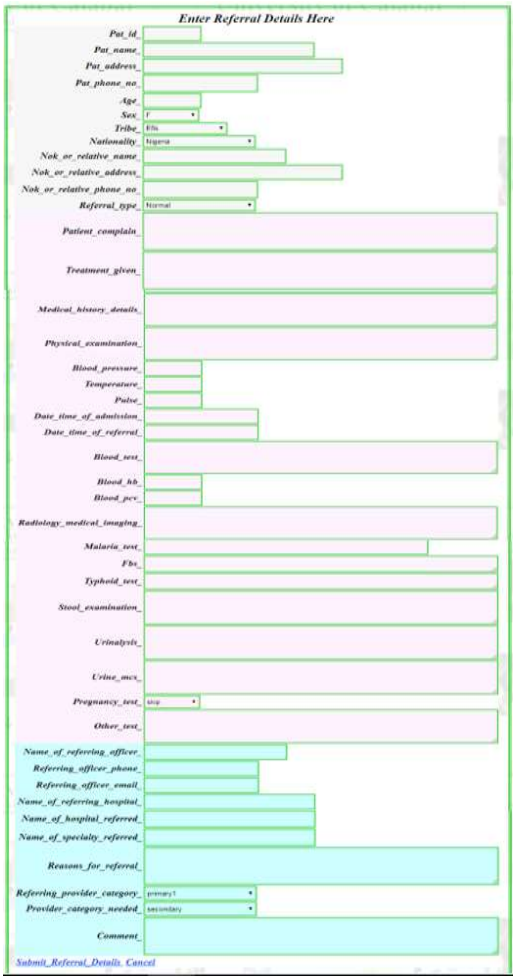


Figure 2: The ERRF As Viewed By The Referring (Sending) Provider.

Where the request input need not be captured, the word *"skip"* is used to fill the blank, since the words *"nil"* and *"none"* may have an interpretation in some diagnostic test results or other reports that may be captured in the ERRF.

- Referrals from primary: The head of each primary health centre (Chief Community Health Officer) filled the necessary fields of the electronic referral request form to initiate referrals and provide the basic data/information of the patients. Some referral request was rejected on the basis of not containing adequate information (Table 1).
- Referrals from secondary: In the secondary health care level, necessary fields of the ERRF were filled by General practitioner or a Chief nurse officer (nurse practitioner). For referral request that were appropriately filled, they were triaged and scheduled for care, otherwise the referral request was redirected back to PCP to provide the required data/information.
- Referral from tertiary: The referrals at this level were mostly inter-specialty, where participants within the same tertiary health care provider refer patients to other specialties. Patient referral to other tertiary health care providers also take place at this level. Figure 3 shows the three-phase referral flow from the primary health care provider to the tertiary health care provider.

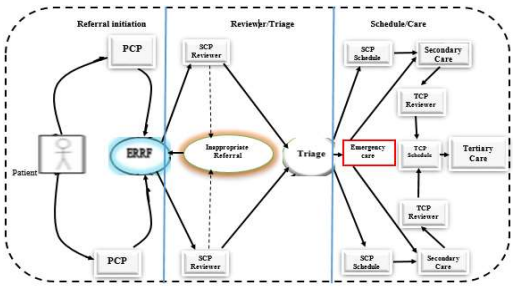


Figure 3: The E-Referral Process Flow Showing The Three Phases.

All the details entered by selected PHC using the ERRF are viewed by secondary provider via the e-Referral system interface.

The feedback mechanism is one of the major innovation of this e-Referral system and is achieved by filling the necessary details using the feedback interface.

Figure 4 shows the main page of the e-Referral platform, where the users start their interactions and navigation. The page made it possible for users in a given category to choose their interface. The specialists also click on their interface to continue their interactions.

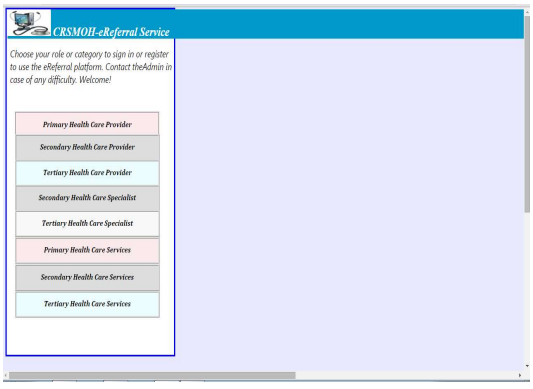


Figure 4: The E-Referral Main Page

3.4.2 The e-referral system testing/evaluation.

The e-Referral system testing was done using strategically selected health care providers within the study area. The e-Referral components testing

was carried out to ensure that the various components performed appropriately. The application was setup with connections at the health care facilities to enable the participants use and interactions with the system.

The e-Referral system testing was organized to ensure the overall interactions with the entire system in terms of data flow, user views, user authentications for access and roles among the three levels.

In order to carry out the test the following were used:

- IIS configurations (local host)
- Android smartphone (as router)
- Wi-Fi hotspot
- Two laptops (one server and one client)
- IP and gateway configuration for the server and client systems.

3.4.2.1 Test environment setup

The test environment was set up for each of the client computer to interact with the server computer. The Internet Information Server for both server/clients computers were configured. This involves launching IIS manager located in the Windows Administrative Tools (Windows O).

1. In the IIS manager environment, the application's virtual directory was configured.
2. A smart (Android) phone was used as a router, using the Hotspot to connect the server/client to the phone.
3. In the server computer, (an IP address and a subnet mask were configured base on the Internet Protocol Version 4 (TCP/IPv4). This was done through the change adapter settings (Wi-Fi properties). The IP address was set as 192.168.1.1 and the Subnet mask was set as 255.255.255.0.
4. The client(s) computer, was also configured (Wi-Fi option) with the following IP address: 192.168.1.2. The last digit of the IP address (for the client systems) takes values from 2 upwards, the digit 1 has already been assigned to the server in this case. The values in the Subnet mask where the same as server. In the Default gateway an IP of 192.168.1.1. was used.

At each level the participants entered the following local IP Address (**192.168.1.1/MOHeReferral**/) to launch the application.

(i) ***First stage***: During the first stage, the primary level participants sent e-referral document to the secondary provider using the network connection that was set up. At the secondary health care level, the e-referral document sent by the primary provider was viewed and studied to enable them take appropriate action and give feedback. The e-referral form was also filled and transmitted to the tertiary level. At the tertiary level, a feedback, in response to the e-referral request was forwarded to the secondary provider and a patient schedule was made as part of the testing process.

(ii) ***Second stage***: The second stage of the testing process involved visiting the primary health care to view and evaluate the feedback from the secondary health care, as well as visit the secondary health care to enable the participant view and evaluate the feedback response from the tertiary health care provider.

The process lasted for six months and this approach facilitated monitoring of the participants' ability to use the platform efficiently. This process ran side by side with paper method for evaluation purpose.

During the testing process, some of the problems encountered were noted as follows:

- the number of errors committed at each health care delivery level.
- the comparison of error commission by the three health care levels.
- the willingness to use the system by the three health care levels.
- the difficulty experienced in the course of using the system at each level.

3.5 The e-Referral Key Factors Influencing Implementation

The study identified five key factors that may influence e-Referral implementation. These five key factors were derived from the research questionnaire by assigning related question(s) to each respective factor.

The e-Referral factors helped to highlight some design/implementation issues such as the computer/ICT compliance level of the health workers and comparison of the three levels of health care delivery.

The e-Referral factors were found to conform to the educational/professional qualifications, which also reflected in the ICT compliance of the health care workers in all the three health care categories.

The key factors identified in this research comprised the following:

(i) Willingness to accept/adopt a new e-Referral system.
(ii) e-Referral awareness.
(iii) Expected improvements on using the new system.
(iv) Difficulties encountered in using the current referral system.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

(v) Computer usage/ICT compliance of health care workers.

The percentages of the key factors served as basis for comparison of the three levels of health care delivery. The pie charts for the respective health care delivery levels are shown in Figure 5, Figure 6 and Figure 7. In Figures 5, 6 and 7, the percentages of the factors are depicted, the willingness to accept/adopt a new e-Referral system measure the extent to which the users at this level are willing to accept or adopt this system when introduced. The e-Referral awareness measure the extent to which the users have prior knowledge or have used any e-Referral system. The expected improvements on using the new system measures the extent to which the users think the referral will improve, based on the advantages of using a computer. The difficulties encountered in using the current referral system - measures the level of difficulty users expressed in using the current paper method. The Computer usage/ICT compliance of health care workers factor measure the level of computer literacy of users.

Figure 5 shows that 39% of primary health care workers expressed difficulty in using the paper based referral document, which sometimes involves cancellations and writing a new referral consumes time. Also, 26% of them expressed willingness to use a new platform such as the e-referral for patient referrals. They felt that being electronic makes it easy to create and send referral, even in the face of cancellations. Likewise, 40% of the primary health care workers indicated that using an electronic platform would bring about improvement in the referral process. However, 9% of the workers indicated that they were aware of the existence of e-Referral system and also 9% indicated that they were computer literate/ICT compliant.

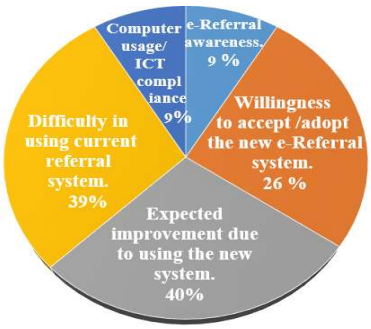


Figure 5: The Pie Charts Of Key Factors Percentage For Primary Provider.

At the secondary health care level (Figure 6), 13% of the workers indicated that they were computer literate/ICT compliant, while 20% expressed difficulty in using the paper based method. This showed 19% decreased from the primary health care workers, and agrees with the fact that, the literacy and competence of health care workers at this level is better than the primary health care level. Again, 25% of the workers indicated their willingness to use a new electronic platform, and 29% indicated that a new electronic system will bring improvement. For both computer literacy/ICT compliant and the awareness of the existence of e-Referral system, they indicated 13%.

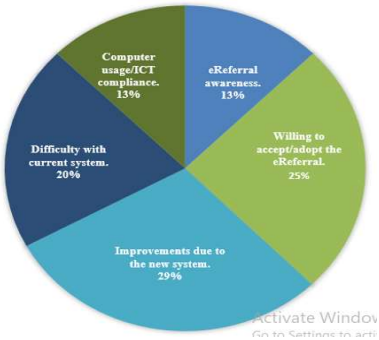


Figure 6: The Pie Charts Of Key Factors Percentage For Secondary Provider

In the tertiary health care level (Figure 7), 23% of workers indicated that they were computer literate/ICT compliant, while 18% indicated that they were aware of e-Referral system. Again, this highlighted the fact that educational/professional qualifications of the health care workers are higher at this level. Also, 16% of health workers expressed difficulty in using the current paper based system, indicating a decreased from that of the secondary health care level, because the competences of the health care workers are highest at this level. On the willingness of the health care workers to use a new electronic platform, 23% indicated and 20% accepted that the new system will bring improvement.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Figure 7: The Pie Charts Of Key Factors Percentage For Tertiary Provider

The overall outcome showed that the level of educational attainment had influence on the performance and usability of the e-referral system. The best performance was achieved by the tertiary health care workers consisting of very highly trained medical professionals, and consultants/specialists who also have high level of computer literacy. The next in performance index are the secondary health care workers consisting of highly trained general medical practitioners and few specialists. The least are the primary health care workers, with little professional training, obtained from basic health institutions. Although the educational level of participants was not directly measured or placed as a criterion in this study, the professional training of personnel for each level of health care delivery differs and clearly imposes some advantages on them.

4. RESULTS

During the period of six months, the referrals from the primary to secondary providers, for the three departments of gynaecology, paediatrics and ophthalmology, showed that 11 out of 47 referrals of the paper based method were submitted with one complain or error (e.g. the treatment given was not clearly captured) or the other. That is about 23.4% of the referrals (see Table 1) were found to have errors. Within that same period the e-Referral system that was used alongside, was found to contain 5 referrals with errors, (e.g. the format for entering the patient id was not correct) giving 10.6% of the total referral within the period.

The referral from secondary to tertiary provider for the same departments showed that 7 out of 25 referrals were with errors for the paper based referrals and 2 referrals were with errors using the e-Referral system. That is 28% and 8% for paper based and e-Referral system respectively. The reduction in the number of errors or percentage due to the use of the e-Referral system at both levels of referral indicates a significant reduction in the number of inappropriate referrals.

The wait times for patients in these departments reduced significantly because the delays and hindrances that normally arise due to unclear reasons for referral or missing referral and other problem associated with paper based referral were resolved with the use of e-Referral system.

The collaboration between providers also increased as the providers were able to send messages and receive feedback speedily via the e-Referrals platform. The medical staff at the tertiary health care centre particularly expressed satisfaction because the e-Referral platform afforded the opportunity for flexible interaction with the lower level providers for more information or input regarding the patient on referral.

The lower level referral (primary-secondary) indicated more error entries, which conforms with the level of ability to use the computer, among other factors, during the e-Referral process. The ability to use the system by participants in the three levels of health care in a short time contributed to the willingness to accept the system.

The results from this study are in line with the many benefits that are witness from other works as indicated in the literature from the two-tier models. These include faster operation in the referral process, enhanced referral structure, reduction of errors, timely delivery of health care and reduced waiting times, collaboration among the three-tiers of health care providers, proper tracking of referrals, speedy feedbacks, easy management of referrals and patients among other benefits. The major improvement includes better communication and health care delivery. This also will lead to the elimination of paper based referral method.

4.1. e-Referral System Usability Evaluation

The usability of the e-Referral was measured using the System Usability Scale (SUS). Usability is defined as the degree of ease with which a user can use certain products such as software, web application, hardware, mobile devices to accomplish the required goal effectively and efficiently.

The system usability testing tool is a 10 – item Likert scale questionnaire that provide an easy assessment of the ease of use of the given product. The SUS value is calculated using the following procedure:

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

(i) For every odd-numbered question, subtract 1 from the score (D_i - 1).
(ii) For every even-numbered question, subtract the score from 5 (5 - E_i)
(iii) Then sum all the new scores obtained and multiply by 2.5 to obtained the SUS score.

Though the SUS score is rated over 100, this value is not a percentage and usually the value of 68 is taken as the acceptable minimum value below which the usability is considered very poor.

For the purpose of testing the usability of the e-Referral system, a Likert scale post-test questionnaire were given to the participants for responses, from which the computation was done using system usability scale. The summary of the SUS score computation for the three levels of health delivery are derived as shown in Table 2.

Table 2: Summary Of SUS Scores For Three Health Care Levels.

Respondent	Respondent Total Score			SUS Score		
	PCP	SCP	TCP	PCP	SCP	TCP
1	29	32	35	72.5	80	87.5
2	28	30	33	70	75	82.5
3	31	33	33	77.5	82.5	82.5
4	31	34	32	77.5	85	80
5	30	28	31	75	70	77.5
6	25	27	30	62.5	67.5	75
7	32	33	32	80	82.5	80
8	31	34	33	77.5	85	82.5
9	31	32	35	77.5	80	87.5
10	25	26	29	62.5	65	72.5
11	22	25	30	55	62.5	75
12	27	28	29	67.5	70	72.5
13	26	29	35	65	72.5	87.5
14	30	32	35	75	80	87.5
15	27	27	32	67.5	67.5	80
Total	**427**	450	**484**	**1062.5**	**1125**	**1210**
SUS Score				**70.8**	**75**	**80.7**

Fifteen respondents were selected from each health care level to compare the usability levels. Table 2 showed that each respondent score (ten questions) and the SUS score in all the health care levels. The SUS score is then computed by taking the sum of respondents' total multiplied by 2.5 or multiplying each respondent total by 2.5, then summing the products and dividing the sum of these products by the total number of respondents.

The result showed that the SUS scores for each level were within the acceptable value of the usability scale (68). The result also showed improvement as you moved from the lower health care delivery level to the highest, conforming with the earlier result that pointed to level of ICT compliance, which is a factor that may enhance the e-Referral usability. Figure 9 depict the bar chart comparing the three SUS values for three health care levels. It indicated that the ability to use the e-Referral platform by health care workers is lowest at the primary health care level, whereas the tertiary health care workers showed the highest ability to use the platform, with workers in the secondary health care level coming in between.

Figure 8 shows a comparison of the usability scores among the three health care levels in this study. It indicates that the primary health care level had the lowest score and the tertiary health level had the highest. This shows that the educational/professional qualifications contribute to the ability of the health care workers to use the platform reasonably.

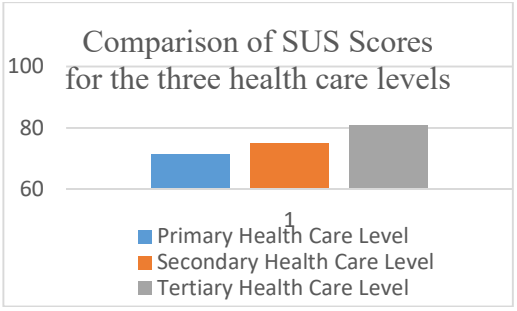


Figure 8. Chart Of SUS Scores For The Three Health Care Levels.

A study was also conducted with another sample of participants in three primary health care levels (PHC Esuk Ekpo Eyo, PHC Ikot Offiong Ambai and PHC Ikot Odo), from nearby communities of Calabar. These participants had not been part of the study and were not part of data collection or trained to use the e-referral system previously. The participants were asked to use the system to create and send an e-referral document that will accessible to a selected secondary health care centre. The participants filled and send e-Referral documents to the nearest secondary health care facility (General Hospital, Ikot Ene), where the referral was viewed, studied and sent feedback using the e-Referral system. The e-referral form was also filled and transmitted to the tertiary. This process also involved visiting the PCPs to view and evaluate the feedback from the secondary health care as well as visit the secondary health care to view and evaluate the feedback from the tertiary level. The same tertiary health care as those who participated was used. This study was carried out in order to assess different performance among potential users and ascertain if the e-referral can improve the referral process for better health care delivery. Post evaluation data (Table 3) was collected for t-test analysis to compare usability by the two groups (participants and non-participants in study) in the primary and secondary health care levels.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

At the primary health care level, an independent samples t-test to compare the two groups using 28 degrees of freedom and alpha level of 0.05. The t-value was 0.54 and p-value was 0.595. The p-value of 0.595 was greater than the alpha-value of 0.05 ($p = 0.595 > \alpha = 0.05$), therefore, we cannot reject the null hypothesis (Ho: $\mu_1 = \mu_2$) that there is no difference between the means of the two samples.

Again, at the secondary health care delivery level, t-test to compare the groups, showed that with 28 degrees of freedom and alpha level of 0.05, the t-value was 0.6276, and p-value of 0.537 which was greater than $\alpha = 0.05$ ($p = 0.537 > \alpha = 0.05$). Hence, we cannot reject the null hypothesis (Ho: $\mu_1 = \mu_2$), there was no significant difference in the mean values of the two samples. The results indicate that the two sample groups were able to use the e-referral system successfully. This will improve the referral process and enhance health care delivery in the three-tier health care system.

Table 3: Data For The T-Test.

Respondent	Respondent Total Score (10 questions)			
	PCP1	PCP2	SCP	SCP2
1	29	28	32	32
2	28	30	30	32
3	31	30	33	30
4	31	30	34	31
5	30	30	28	30
6	25	28	27	29
7	32	33	33	31
8	31	33	34	33
9	31	31	32	29
10	25	26	26	28
11	22	25	25	22
12	27	25	28	27
13	26	27	29	31
14	30	28	32	29
15	27	29	27	26

Within the six months monitoring period, a total of 72 e-referral were sent, 47 from two selected Primary Heath care centers to one Secondary health care center. Out of that, 36 of these cases were successfully handled and prompt care given to the patients. Also 25 e-referrals were sent from the Secondary care center to the tertiary health care provider. And out that 18 cases were promptly handled and required care given to the patients. This results shows a decrease in error rate from 51.4 % with the use of the paper referral to 18% with the use of the e-referral. This shows improved efficiency in the preparation of referrals. Overall, this has improved the interactions, accuracy and handling of referral cases in the health centers.

5. DISCUSSION

The paper referral method has been found to be plagued with numerous problems, the e-Referral system was developed to improve the referral process in three-tier health care delivery system, using computer technology. Literature has shown that many well developed heath care systems have successfully harnessed computer technology to gain significant improvements in their health care delivery system.

The motivation for the study was based on the fact that existing referral models encountered were tailored to fit specific health care delivery systems, hence the need for this model which is developed to suit the existing health care delivery systems, especially the less developed health care systems, most of which are three – tier model.

The enforcement of referral policies among the health care delivery levels was one issue that was found to make the e-Referral implementation even more difficult. Patient easily move from low level health providers to tertiary health providers without regulations. Though it was observed that poor health care facilities and lack of adequate personnel always give rise to the unregulated movement. Effort toward improving the health care facilities may enhance the e-Referral implementation and reduce strain on the tertiary level.

Stakeholders discretion was essential in achieving a well-coordinated e-Referral system and this resulted in modifications in the user interfaces, which allowed the users in the three tiers to use the e-Referral effectively. Visiting the various selected health facilities to consider the peculiarities as well as the organizational structure of each tier fundamentally contributed to the development.

6. CONCLUSION

Several e-referral models have been developed and successfully applied in different health care delivery systems. In countries with national electronic health records EHR, electronic referral may be embedded, whereas others are independently developed with intention to merge with EHR or expanding the e-Referral into full fledge EHR. Developing an e-Referral system in environments where computer literacy is considered low, was a major challenge. Some health workers felt threaten of losing their jobs, making them reluctant to provide the needed data/information. In one instance, access to the referral form was denied, despite ethical approval from the authorities, indicating the level of resistance. A reasonable number of health workers felt the new system was necessary and showed interest in using the system. The participants overcame the fear of the use of computer as they found that the system was easy to learn and interact

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

with. The speed of referral information dissemination, the security, ease of interaction among the health care delivery levels, the intercommunication among other benefits, motivated the participants and influence the willingness to accept/adopt the new system.

The e-referral model has high potentials in improving health care delivery, enhance the referral process, provide timely interventions to patients' conditions and bridge the communication gap among the providers. While there are still challenges that need to be resolved for a successful implementation of an e-referral system such as provision of the required IT infrastructures, and enhance computer literacy. The e-referral system provides for bi-directional communication through a feedback mechanism to enable proper monitoring of referred cases. The system testing and evaluation results shows that the participants were able to send and receive a well-structured and documented e-referral document with adequate information. This will eliminate loss in transit of referral document occasioned with the paper referral. The e-referral will enhance understanding, information flow and enhance health care delivery. The use of non-participating health care centres reinforce the usability of the e-Referral system, thereby making it necessary for adoption and implementation. Although the study strives to eliminates most issues identified in the paper based method of patient referral, other challenges such as computer literacy level of health care workers, especially at the primary health care delivery level and sensitization in the use of e-referral system, were difficult to handle adequately.

REFERENCES

[1] Emerson, H., Brantley, E., & Schrag, J., (2016). Increasing access to specialty care through collaboration: e-referral and e-consult. *The National Partnership for the Health Care Safety Net, 2 (1)*, 1-6.

[2] Chen, A. H., Murphy, E. J., & Yee, H. F. Jr., (2013). eReferral — A new model for integrated care. *The New England Journal of Medicine*, *26,* 2450 - 53.

[3] Liu, C., Long, A., Li, Y., Tsai, K., Kuo, H. (2001). Sharing patient care record over the world wide web. *Internal Journal of Medical Informatics. 6,*189-205.

[4] Akbari, A., Mayhew, A., Al-Alawi, MA., Grimshaw, J. M., Winkens, R. A. G., Shirran, E.A., Glidewell, E., Pritchard, C., Thomas, R., & Fraser, C. (2009). Interventions to improve outpatient referrals from primary care to secondary care. *Cochrane Database of Systematic Reviews.* John Wiley & Sons, Ltd., p. 3.

[5] Darcy, N., Kelley, C., Reynolds, E., Cressman, G., & Killam, P. (2010). An Electronic Referral Application: a case study from Zambia. *Research Triangle Institute International.* RTI Press. Zambia, pp. 3-5.

[6] Heimly V. (2008). Standardization, innovation and deployment of electronic referral software in Norway. *Journal of Telemedicine and Telecare, 14*, 359–362.

[7] Diaz, J., Fava L., Luliano, P., & Rosso J. H. (2011). A patient referral and counter referral management system for hospitals. *International Conference on Enterprise Information Systems. 2,* 2-7.

[8] Bell, D., Straus, S., Wu, S., Chen, A., & Kushel, M. (2012). Use of an electronic referral system to improve the outpatient primary care – specialty care interface. *Agency for Healthcare Research and Quality AHRQ, 1 (12)*, pp.1-39.

[9] Scheibe, M. M., Imboden, J B., Schmajuk, G., Margaretten, M., Graf, J. D., Chen, A H., Yelin, E.H., Yazdany, J. (2015). Efficiency gains for rheumatology consultation using a novel electronic referral system in a safety-net health setting. *American College of Rheumatology. 67 (8),* 1158-63.

[10] Babbie, E. R. (2011). The logic of sampling. *The basics of social research.* (5th ed./Instructor's ed.). Australia: Wadsworth/Cengage Learning. pp. 41-61.

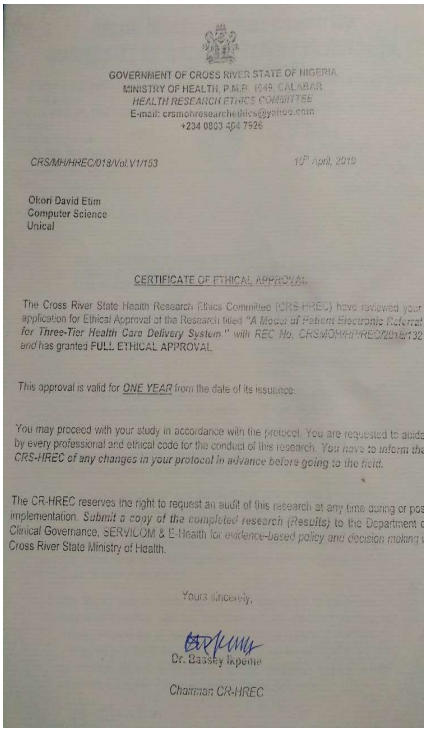
[11] Rose, S., Spinks, N. & Canhoto, A. I. (2015). Applying quantitative and qualitative research designs. *Management Research: Applying the Principles.* New York: Taylor & Francis Group. pp. 240 – 255.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 1: Percentages Of Errors Committed In Two Stages Of Referral Interaction.

Referral Level	Number of referrals	No. of errors committed	Percentage error (paper-based)	No. errors committed (e-Referral)	Percentage error (e-Referral)
Primary - Secondary	47	11	23.4	5	10.6
Secondary – Tertiary	25	7	28	2	8
Total	**72**	**18**	**51.4**	**7**	**18.6**

Appendix A: Ethical Approval Letters From Ministry Of Health And The University Of Calabar, Teaching Hospital.



GOVERNMENT OF CROSS RIVER STATE OF NIGERIA
MINISTRY OF HEALTH, P.M.B. 1049, CALABAR
HEALTH RESEARCH ETHICS COMMITTEE
E-mail: crsmohresearchethics@yahoo.com
+234 0803 454 7926

CRS/MH/HREC/019/Vol.V1/153 10th April, 2019

Okori David Etim
Computer Science
Unical

CERTIFICATE OF ETHICAL APPROVAL

The Cross River State Health Research Ethics Committee (CRS-HREC) have reviewed your application for Ethical Approval of the Research titled *"A Model of Patient Electronic Referral for Three-Tier Health Care Delivery System"* with REC No. CRSMOH/HREC/2019/132 and has granted FULL ETHICAL APPROVAL.

This approval is valid for ONE YEAR from the date of its issuance.

You may proceed with your study in accordance with the protocol. You are requested to abide by every professional and ethical code for the conduct of this research. You have to inform the CRS-HREC of any changes in your protocol in advance before going to the field.

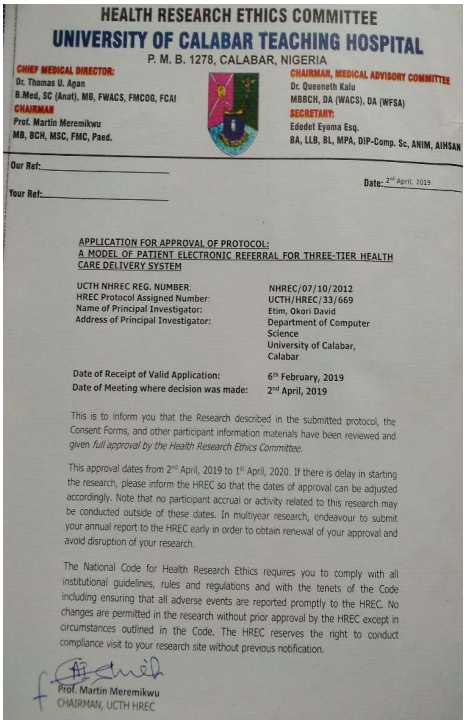
The CR-HREC reserves the right to request an audit of this research at any time during or post implementation. Submit a copy of the completed research (Results) to the Department of Clinical Governance, SERVICOM & E-Health for evidence-based policy and decision making in Cross River State Ministry of Health.

Yours Sincerely,

Dr. Bassey Ikpeme

Chairman CR-HREC

Figure 9: Ethical Approval Letter From Ministry Of Health, Head Quarters, Calabar.



HEALTH RESEARCH ETHICS COMMITTEE
UNIVERSITY OF CALABAR TEACHING HOSPITAL
P. M. B. 1278, CALABAR, NIGERIA

CHIEF MEDICAL DIRECTOR:
Dr. Thomas U. Agan
B.Med, SC (Anat), MB, FWACS, FMCOG, FCAI
CHAIRMAN
Prof. Martin Meremikwu
MB, BCH, MSC, FMC, Paed.

CHAIRMAN, MEDICAL ADVISORY COMMITTEE
Dr. Queeneth Kalu
MBBCH, DA (WACS), DA (WFSA)
SECRETARY:
Ededet Eyoma Esq.
BA, LLB, BL, MPA, DIP-Comp. Sc, ANIM, AIHSAN

Our Ref:
Your Ref:
Date: 2nd April, 2019

APPLICATION FOR APPROVAL OF PROTOCOL:
A MODEL OF PATIENT ELECTRONIC REFERRAL FOR THREE-TIER HEALTH CARE DELIVERY SYSTEM

UCTH NHREC REG. NUMBER: NHREC/07/10/2012
HREC Protocol Assigned Number: UCTH/HREC/33/669
Name of Principal Investigator: Etim, Okori David
Address of Principal Investigator: Department of Computer Science, University of Calabar, Calabar

Date of Receipt of Valid Application: 6th February, 2019
Date of Meeting where decision was made: 2nd April, 2019

This is to inform you that the Research described in the submitted protocol, the Consent Forms, and other participant information materials have been reviewed and given *full approval by the Health Research Ethics Committee.*

This approval dates from 2nd April, 2019 to 1st April, 2020. If there is delay in starting the research, please inform the HREC so that the dates of approval can be adjusted accordingly. Note that no participant accrual or activity related to this research may be conducted outside of these dates. In multiyear research, endeavour to submit your annual report to the HREC early in order to obtain renewal of your approval and avoid disruption of your research.

The National Code for Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations and with the tenets of the Code including ensuring that all adverse events are reported promptly to the HREC. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit to your research site without previous notification.

Prof. Martin Meremikwu
CHAIRMAN, UCTH HREC

Figure 10: Ethical Approval From The State University Of Calabar Teaching Hospital, Calabar.