A Patient-based Hospital Referral Decision Support System

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ABSTRACT
In this study, an electronic referral system was developed for general practitioners to send referrals electronically to providers. The electronic referral system aims at improving referral decisions by involving patients in the process. A database of hospital services in Lagos metropolis was developed and hospitals distance information were retrieved and computed using Google map. A provider selection model that uses a multi-attribute decision making function was adapted and implemented. The provider selection model selects optimal provider based on patients and providers determinants which contained fourteen criteria for referral decision. In the system's output, hospitals were ranked by computing the average between provider and patient feedback factors, this differs from existing systems as the implemented system shows how introduction of patient participation can affect recommended hospitals. In conclusion, the result of this work is expected to improve referral decision support and patient participation.

General Terms
Health Information System, Health Informatics, Consumer Health Informatics.

Keywords
E-Referral; decision support system; patient-based.

1. INTRODUCTION
Healthcare Referral system supports the mobility of patients between varieties of health care providers [1]. It is one of the main health systems that assist in ensuring that consumers receive adequate, low-cost and timely services delivery with the most appropriate provider [2, 3]. A referral process involves the transfer of patient care from a primary care provider (PCP) with insufficient resources to another provider adequate or sophisticated resources [4]. The paper referral process have limitations such as inadequate information, lost or misplaced paper records, long wait times from delay in specialist feedback, and medication errors resulting from illegible handwritings [5, 6, 7, 8]. In order to resolve these challenges, E-Referral (ER) has been proposed as the solution to paper based referrals.

ER is an electronically transmitted message such as documents that enables the transfer of patients' information from a PCP to a specialty provider or hospital [8, 1]. ER is designed to improve communication between PCP and specialists', improve documentation quality and seamless exchange of information, decrease wait times, enhance medical decisions and facilitate urgent cases [9].

Several promising ER systems have been developed for variety of health services [10, 11, 12, 13]. ER process is a complex and critical activity which involves referral decisions and referral communications [14, 15, 16, 17]. A referral decision is a clinical decision made by physicians about whether the referral is needed or not, and the choice of specialist. Referral communication deals with the further interactions that exist between the PCP and the specialist once a referral decision is made. The complexity of the process often leads to inefficient referral decisions and referral communications which in turn affects the quality of health care service. Modern-day definition of healthcare encourages the active participation of patients in decision process in order to enhance their state of health and efficiency of the health care system [18, 19, 20, 21].

Studies have shown that participation of patients in health care has been associated with improved treatment outcomes [22, 23]. Most of the existing ER research concentrate on how to improve referral communication and there has been little or no room for patients' participation in the referral decision process. Therefore, these systems select the best hospitals or specialists without including patient experience surveys [24, 14, 15, 25, 26]. This paper focuses on improving referral decisions and involving patient in the process of the decision making.

ER systems have been used to support PCPs in choosing consultation clinics or specialists who can better address their requests. One method used to address this requirement is providing a directory of specialist information, including distance and average wait times and making it possible to filter and search through the list. This method has been widely used in two national e-referral and scheduling systems ZorgDomein in Netherlands and Choose and Book in England [8]. There has been a narrowed review of the literature closely relating to the development of Decision Support System (DSS) for use in the ER system. [25] reported on constructing a DSS that uses a Prediction and Optimization-Based Decision Support System (PODSS) algorithm, which is able to function without an explicit knowledge that can assist with the selection of hospital-selection decision. The algorithm obtains knowledge on its own by building machine learning classifiers using known outcomes from previously solved cases to form a predictive model and a validation map which is used to estimate the probability of a desired outcome for and patient. This knowledge is stored in form of a mathematical function and, in responding to a query asked by the user, the query uses the optimization algorithm to find the optimal choice of hospital which maximizes the probability of the desired outcome. The authors noted that a good hospital referral recommendation should consider not only institutional factors but also patient factors, including the travel distance a patient can tolerate, and the patient's risk factors. However, there are some pitfalls in [25] the algorithm concerned patient

survival and free-from-complication probabilities under the constraint of maximum tolerated distance to a hospital. Also, the algorithm developed was for a single, specific condition and is limited to a specific type of disease, area, and time period [26].

[15] addressed how to extend the capabilities of current e-referral systems with referral decision support by adopting the emergent multi-agent technology. The work presents a Multi-Criteria Provider Selection (MCPS) model which employs a three-stepped hierarchical search, policy based filtering, and Multi-Attribute Utility Theory (MAUT) based Multi-Attribute Decision Making (MADM). The author emphasizes that referral decision process is always affected by a complex mix of patient, physician, provider and system determinants which operates in an environment of distributed and dynamic network of health-care providers. They proposed a multi-agent approach for automating the process. The challenge of this approach was in the selection model because the location of providers defined in terms of the national political structure (geographical location) which indicates actual distance was not included. As a result, providers situated in the same political location are considered to have an equal performance score in terms of the location parameter. In addition, during the three-stepped hierarchical searching, providers outside the region being searched but that might be closest to the referring provider are not considered. There is a need to improve the proposed searching technique so that actual distances of providers will be considered.

This paper aims at developing a patient-based hospital electronic referral decision support system that is capable of improving referral decisions and overall quality of health care.

2. DESCRIPTION OF THE PROPOSED PATIENT E-REFERRAL SYSTEM (PERS)

The PERS shown in Figure 1 is designed to enable the transfer of patient referrals between healthcare providers electronically and to optimize the selection of providers. The system is web-based enabling all health care practitioners as well as patients to be able to access the system from anywhere. The two major layers in the PERS are the PERS layer and decision support system layer.

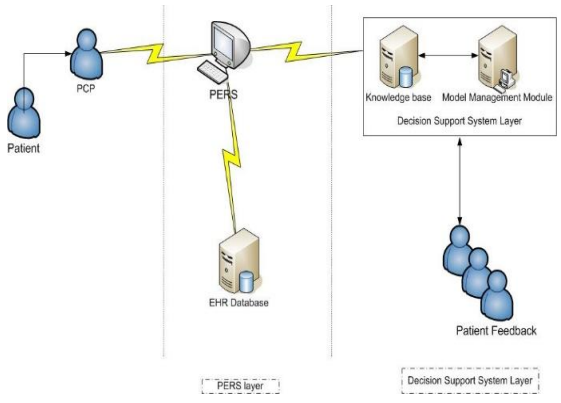

Figure 1: System Architecture of the Patient E-Referral System (PERS)

2.1 PERS Layer

The PERS layer interface handles electronic transfer of patient referrals between healthcare providers. In this layer, healthcare providers can initiate ER process, send e-Referral request, provide e-Referral reply, track status of ongoing e-Referrals, and review previous e-Referral communications.

2.2 Decision Support System Layer

The decision support system layer provides referral decision support to the PERS layer. The decision support system layer consists of the knowledge base and the model management module. The knowledge base contains all the information about providers that is, their location, specialty level, provider level and the feedback from patients' experiences. The model management module contains the decision context and user criteria. In this module, a multi-attribute decision making function builds a decision matrix to evaluate and prioritize the list of alternative providers based on given criteria.

2.3 Provider Selection Module

A provider selection module in Figure 2 is built in the model management module that defines the selection criteria for specialist provider selection. Three phases are involved in the provider selection, and this includes:

i. Patient Determinants Phase

ii. Provider Determinants Phase

iii. Patient Feedback Phase

The patient determinant phase search for potential providers that are suitable for the required service (service-suitable providers) based on patient determinants. Then, the provider determinant phase applies a multi-attribute decision making function method on the service-suitable providers to shortlist potential providers based on provider determinants. Finally, the patient feedback phase applies a multi-attribute decision making function method on the suitable providers (shortlisted from provider determinants) based on patient's feedback to produce a list of more refined providers. The list of providers obtained from provider determinant phase and the patient feedback phase are computed together and averaged to give a final ranked list of suitable providers. This list will be provided to the referring provider as a recommendation for a final decision.

Table 1 – 3 presents the provider determinants phase criteria, Table 4 the Patient feedback phase criteria, Table 5 – 6 the multi-attribute decision making function of the proposed selection criteria for provider determinant and patient feedback respectively.

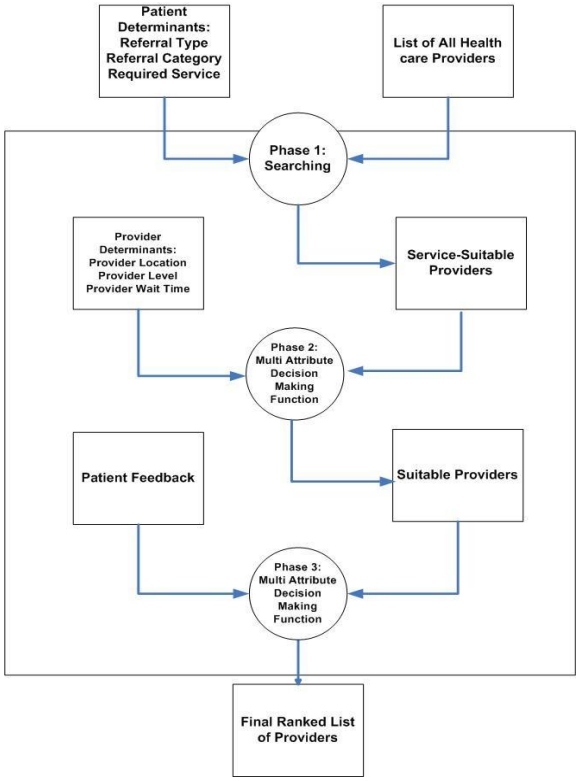

Figure 2: Provider selection model (adapted from [15])

Table 1. Attribute measurement value scale for provider location

Proximity to Referred-to-Provider	Value
Specialist provider is located at desired location	1
Specialist provider is located 5km or less from desired location	0.8
Specialist provider is located 10km or less from desired location	0.6
Specialist provider is located in the same city as desired location	0.4
Specialist provider is located 50km or less from desired location	0.2
Specialist provider is located more than 50km from desired location	0

Table 2. Attribute measurement value scale for provider wait time

Waiting Period	Value
No wait time	1
Less than a week	0.8
1-2 weeks	0.6
3-4 weeks	0.4
More than 4 weeks	0.2
More than 12 weeks	0

Table 3. Attribute measurement value scale for provider level (Patient determinants phase criteria)

Provider Levels	Value
Tertiary Care Provider TCP	1.0
Secondary Care Provider SCP	0.7
Primary Care Provider PCP	0.3

Table 4. Attribute measurement value scale for patient feedback (Patient feedback phase criteria)

Patient Feedback Criteria	Excellent	Good	Average	Poor	Very Poor
Access	1.0	0.7	0.5	0.3	0
Safe & Effective	1.0	0.7	0.5	0.3	0
Wait Times	1.0	0.7	0.5	0.3	0
Satisfaction	1.0	0.7	0.5	0.3	0
Doctors Experience	1.0	0.7	0.5	0.3	0
Nursing Experience	1.0	0.7	0.5	0.3	0
Pain and Comfort Levels	1.0	0.7	0.5	0.3	0
Admission Process	1.0	0.7	0.5	0.3	0

Table 5. Proposed selection criteria for provider determinant

Weight Emergency referral	Weight Regular referral	Selection Criteria	Service Suitable Providers			
			P1	P2	P3	P4
40%	35%	Provider location	0.4	0.4	0.6	0.2
35%	40%	Provider wait time	0.8	1	0.4	0.6
25%	25%	Provider level	0.7	1.0	1.0	0.3

Table 6. Proposed selection criteria for patient feedback

Weight	Selection Criteria	Service Suitable Providers			
		AP 1	AP 2	AP3	AP4
15%	Access	0.7	0.7	0.5	0.5
12%	Wait time	0.5	1	0.5	0.5
12%	Satisfaction	0.5	0.7	0.5	0.7
12%	Safe and effective	0.3	0.5	0.7	1.0
13%	Doctors Experience	0.5	0.7	0.7	1.0
12%	Nursing Experience	1.0	0.5	0.7	0.7
12%	Admission process	0.5	1.0	0.5	0.5
12%	Pain & Comfort Levels	0.3	0.7	0.5	0.7

3. SYSTEM IMPLEMENTATION

PERS is a web application designed using JavaScript and Mongo database. The PERS consists of three main users: the PCP or physician, the patient and the administrative physician. The administrator is the person that oversees the overall operation that takes place in the PERS. The administrative user has the right to view all the referrals sent by a PCP to another healthcare provider, as well as all the referrals coming in to the hospital. He or she also has the right to add new physician to the system, store and forward a referral to the appropriate physician in the hospital and add new patients.

The PCP can log in, view existing referrals, view patient's EHR, initiate a referral and send the referral to the appropriate healthcare provider. After the patient's referral, patients can log in to the system to give feedback concerning their healthcare experience using their patients ID.

3.1 Referral Initiation

Figure 3 shows a patient electronic health record (EHR) retrieved from an EHR database. A PCP can view patient existing health record and then initiate a referral.

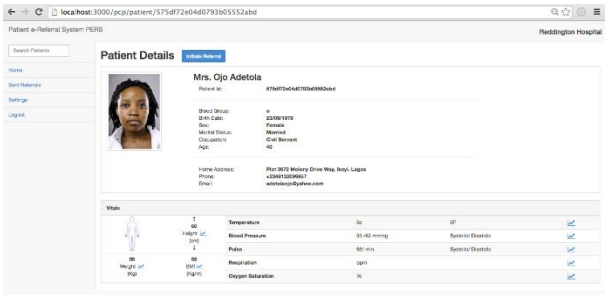

Figure 3: Patient record retrieved from an EHR database

3.2 Provider selection

After the PCP initiates the referral, he or she enters patient determinants details such as Diagnosis (Pelvic Inflammatory Disease), the required services (Obstetrics, Surgery), Referral Type (emergency or regular), Referral Category (inpatient or outpatient) and then selects an appropriate provider. In selecting the provider, this is where the Provider Selection module in the decision support layer as shown in Figure 2 computes the values of providers by using the patient determinants entered by the PCP to search potential providers for the required service, referral type and referral category and then shortlists and ranks the potential providers based on provider determinants and patient feedback. The decision support layer gives a display of ranked providers to the PCP. Once the provider has been chosen, the PCP then sends the referral. Additional notes and files could be attached to the referral as shown in Figure 4.

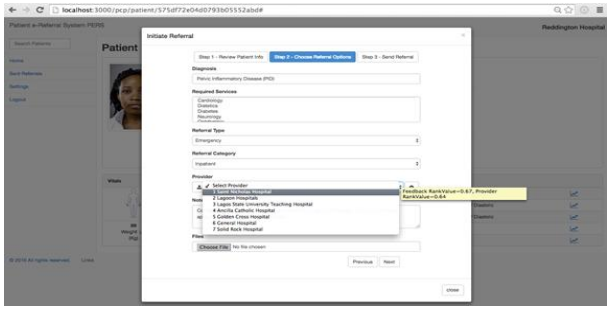

Figure 4: PERS referral page

3.3 Referral Review

Once the PCP in the referring-to provider sends the referral, the administrator in the referred-to provider/hospital receives the referral. The administrator can view the details of the referral and then send the referral to the appropriate physician in the referred-to hospital. It contains a 'Send To' bar to select the physician in which the referral will be sent to. Figure 5 shows the page where the administrator sends the referral to a physician in the hospital. Figure 6 shows the page where the physician in the referred-to hospital can view details of the referral and can either accept or reject the referral. Once the referral has been accepted or rejected by the referred-to provider, the status of the referral changes in the referring provider 'list of referrals' page. The status of the referral changes from pending to Accepted as shown in Figure 7.

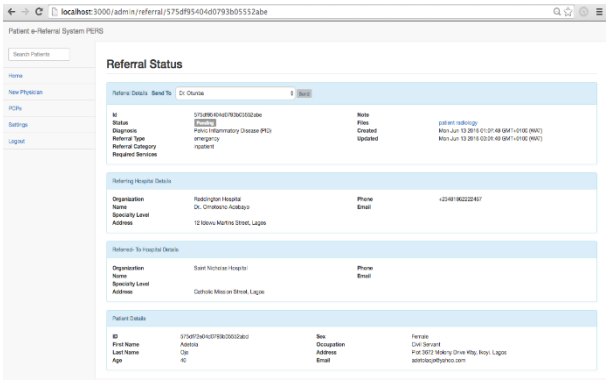

Figure 5: Administrator page forwards referral to appropriate physician in the hospital.

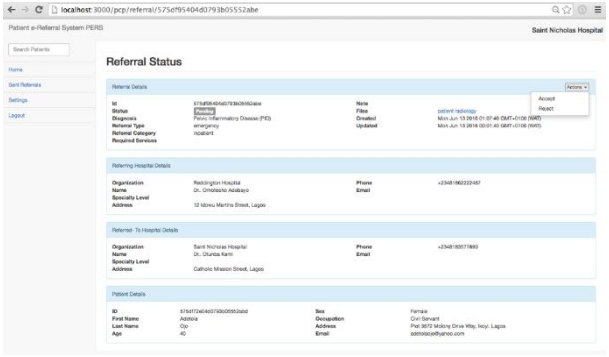

Figure 6: Physician accepts or rejects referral.

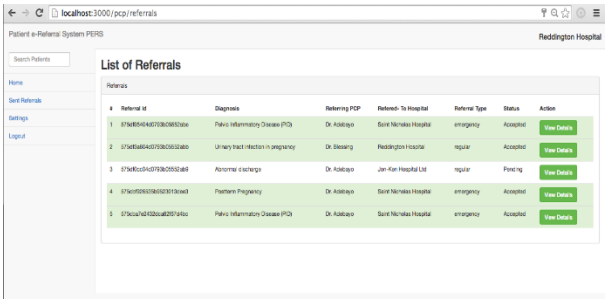

Figure 7: Referring provider page list of referrals page

3.4 Patient Feedback

After the referral, the patient can log in to the feedback page and give feedback concerning their health care experience. Figure 8 shows the patient feedback survey page. It contains the criteria for measuring patients' health care experience such as Accessibility of the referred-to provider, Admission process, Doctors experience, Nursing experience, Pain & Comfort levels, Satisfaction, Safety & Security, and Wait times. Patients selects from a drop down menu the medical provider, and then values for each criteria. The values obtained from the patient feedback survey are imported into the provider selection module (in Figure 2) for patient feedback and are taken into account in future referral list computations.

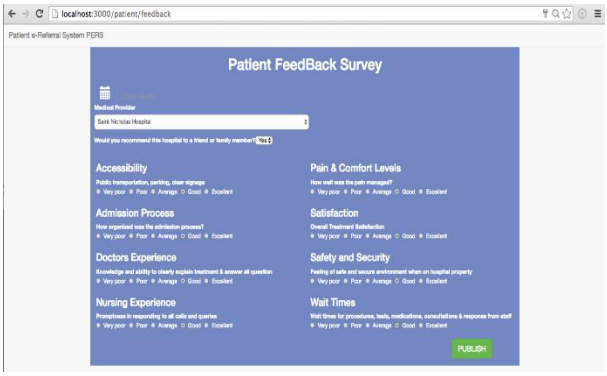

Figure 8: Patient feedback survey page.

4. EVALUATION RESULTS

The graph in Figure 9 shows a comparison between the suggested rank of hospitals for some inpatient emergency referral with and without patient feedback in ER. From the graph, a list of 10 hospitals were displayed with 0.8 being the highest rank value and 0 being the lowest rank value. The green line shows the rank of hospitals based on provider determinants only while the blue line shows the rank of hospitals based on provider determinants and patient feedback. The graph shows that the higher value means best hospitals or hospital with the best quality service. When comparing the average rank value with the provider rank value, we can infer that patient feedback is capable of affecting the rank of hospitals which can further influence better decision making of health care which in pro rata could improve healthcare outcomes and health service delivery.

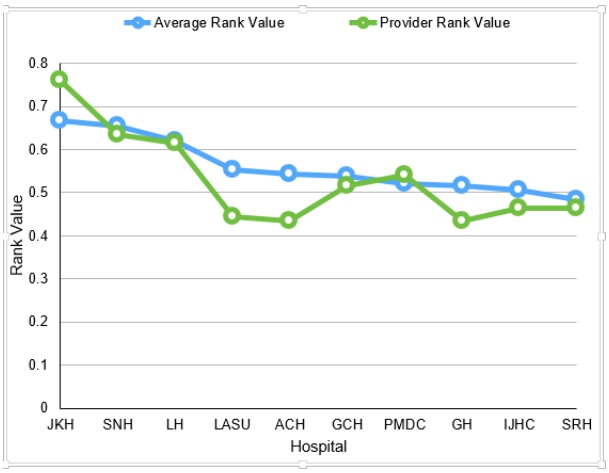

Figure 9: Graph showing emergency referral for inpatients.

5. CONCLUSION

This work focused on supporting physicians in the patient referral process by implementation of patient-based decision support hosted by an electronic referral system in order to check feasibility of the proposed model. The patient e-referral system (PERS) automates the manual referral process by providing a platform in which primary care providers can initiate and send a referral electronically. The PERS is designed to aid physicians in their decision making of selecting the most appropriate healthcare provider for a required service by using criteria such as patient determinants, provider determinants and patient feedback to select the appropriate provider. Also, a patient feedback survey platform was designed to allow patients' participation in their healthcare. The values obtained from the patient feedback survey was further used to influence the decision of selecting appropriate providers. Patient social participation is capable of improving health care outcomes as demonstrated from the implementation result, patient feedback is capable of improving hospital rating for a particular service. This work supports the significant results of including patients interest in determining health outcome reported in [27]. With patients' giving feedback about their healthcare experience, the quality and integrity of providers can be determined thus, can further improve the selection of an appropriate provider for a required service.

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