Nueva Ecija Provincial Health Office: Health Management System with Web-Based and Mobile Application

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Abstract: Health problems are very paramount in any place, especially in the province of Nueva Ecija. Therefore, this study intends to raise awareness in the community about the health status of the Novo Ecijano's and serves as a link among the community-based health workers of each municipality and city health offices. It includes a Thematic Map feature to monitor the health status and generate reports needed by the Provincial Heath Office for the prevention of the different diseases present in a number of its population. This also determines the needed stock of vaccines based on the demand history in a municipality or city that will help in preventing the specific diseases with more cases. Aside from this, updates about the health awareness programs can be uploaded and seen online. A mobile application for the community health workers was also integrated in the system to send a notification on the next follow-up consultation and scheduled vaccines for the patient. Based on the findings, all the features integrated in the project were rated as very satisfied and satisfied. Evidently, the integration of the different technologies solves the pressing public health concerns faced by the province of Nueva Ecija.

Keywords: Electronic Medical Record, Public Health Informatics, Public Health Management System, Public Health Web-based and Mobile Applications, Public Health Big Data and Public Health Geographical Information System

1. Introduction

Technology today impacts every last piece of current society. In fact, there is not an industry out there that has not been affected by its advancement. Whether we are examining transportation, communication, security, managing an account, or human services, they all depend on innovation in one way or another. Such an effect can be clearly seen in the field of medicine and public health [3].

Public health is concerned with the discipline of preventing the spread of infections, prolonging life, and improvement of human health undertakings, commitments, and scientific decisions of its stakeholders, be it the public or private sectors, groups, and individuals. Also, public health aims to decrease risks and enhance the individual's welfare and prosperity. The work crafted by general public health experts is essential since general wellbeing activities influence individuals consistently in all aspects of the world. It tends to raise issues that can influence people, families, groups, populaces, and social orders—both now, and for ages to come. Also, public health enhances the well-being states of individuals locally, broadly, and internationally.

To improve the health and personal satisfaction of the community, medicines and vaccinations have been produced to treat infections and prevent the spread of harmful diseases. However, though a good number of treatments, medicines, and vaccinations have been provided, problems in public health arise. Today, proper health monitoring is not that effective and efficient. But who is really responsible for man's healthcare? Is it simply a matter of individual decision or do governments have a part to play? Do organizations, businesses, and health professionals have duties? Surely, it is an undeniable truth that health ignorance causes lifetime loads. All the more, poor system design proposes an absence of worry by the association or can be viewed as poor service quality. Undeniably, only what gets measured gets attention. It is evident that only what gets recorded or documented and disseminated gets the attention of the policymakers and health care service providers [4].

Likewise, there is a need to interface the public health data created by the community health workers and their supervisors to improve the quality of delivering community-based health services with the help of mobile technology [5].

2 Methodology

2.1 System Development Tools

Development tools and software were used in developing the proposed system. These were utilized to better analyze the system needs. The proposed health management system was constructed with the use of web-based

application technology in the fourth phase of agile development. Laravel 5.2 Framework for PHP, Bootstrap, HTML5, AngularJS, JavaScript, and PHP Mailer for the web-based application to be maintained by the Public Health Office of Nueva Ecija. The mobile application for the community-based health workers used Mobile Ionic Framework in developing the mobile application together with RESTFUL Web Service for open protocols and standards used for exchanging data between applications or systems. This web service uses HTTP methods to implement the concept of REST architecture. This technology will create a mobile application for the version of Android mobile phone users. MariaDB for database engine and storage of the data was done through Cloud Infrastructure. Node JS was used to create API between Web-based Application and Mobile Application.

2.2 Software Development Methodology

Agile Approach Development was used in developing the system. This strategy focuses on adapting to the changing nature of goals rather than predicting ahead of time what those goals will be. This was done by employing an iterative process in which goals were re-evaluated as necessary to move the project forward. As expressed by Sommerville (2015), agile methodology generally depends on progressive undertakings to the specification of software, development, and distribution. This methodology is best for developing a system whose requirements are changing rapidly. Its purpose is to quickly bring running software to the customer, who can suggest a different or additional requirement to be incorporated in the next revision of the system.

Fig 2. Phases of the agile approach development.

Through agile approach development (See Fig. 2), the researchers was able to do the following phases:

2.2.1 Requirements Analysis Phase, the researchers explored the environment and asserted conviction for the possible problems to arise. The community-based health workers and public health provincial officials indicated their needs that they wished to be addressed during the first release using story cards. Each story card describes a feature to be added to the program. In this phase, the researchers determined the user requirement and system requirement needed in the project [7]. Use Case Diagram (UML) used by the researchers to identify, clarify, and organize the system requirements. Use case diagrams are engaged in UML (Unified Modelling Language), model details for the modeling of real-world objects and systems (See Fig. 1). Relational Database Tables are essential components of the system as these serve as the repository of the enormous amount of data that contain all information and transactions of the system.

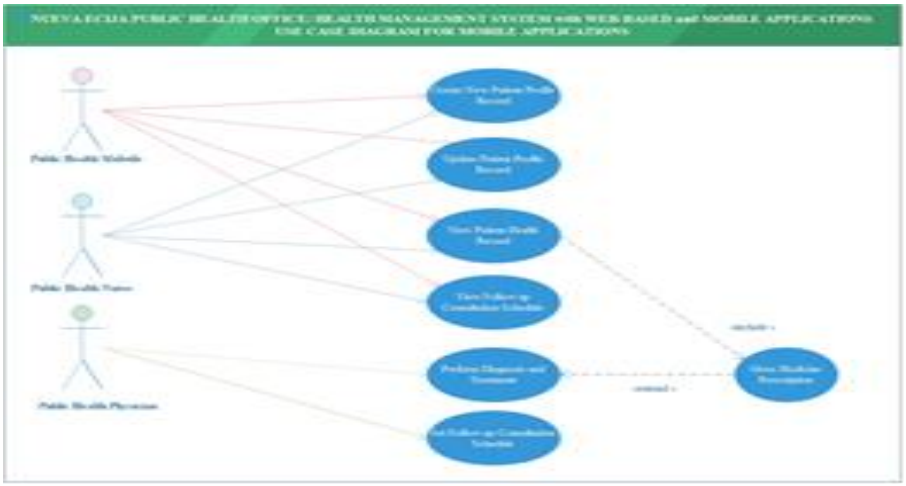


Fig 1. Use Case Diagram of the System.

2.2.2 Planning Phase, the second phase in agile development is the planning phase. It sets the priority order for the stories and an agreement of the contents was made for the first small release. The process of estimating how

much effort in each story was required and the schedule was then agreed upon. Also, familiarization with the tools, technology, and practices that were utilized in the system.

2.2.3 Design Phase

The third phase in agile development describes the structure of the software to be implemented, the data models and structures used by the system, the interfaces between the system mechanism, and the algorithms used. The content of the study was not able to work with a finished design immediately but developed the design iteratively instead. Also, added formality and details in developing the design with constant backtracking to correct earlier designs. The researchers implemented an architectural design for the proposed project and the web-based applications were administered by the Provincial Health of Office of the Nueva Ecija official program members.

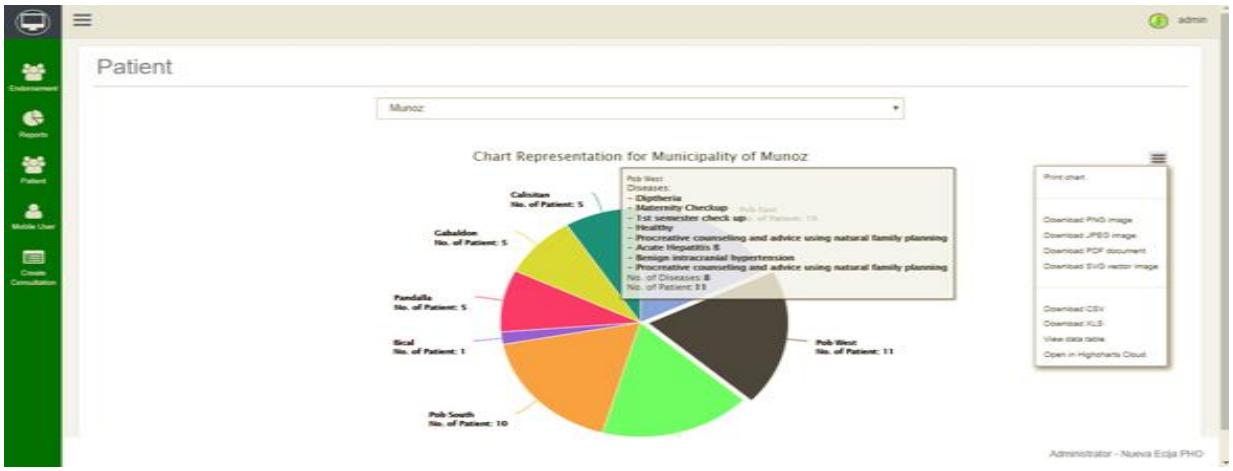


Figure 3. The Key Features of Web-based Application for Admin Facility

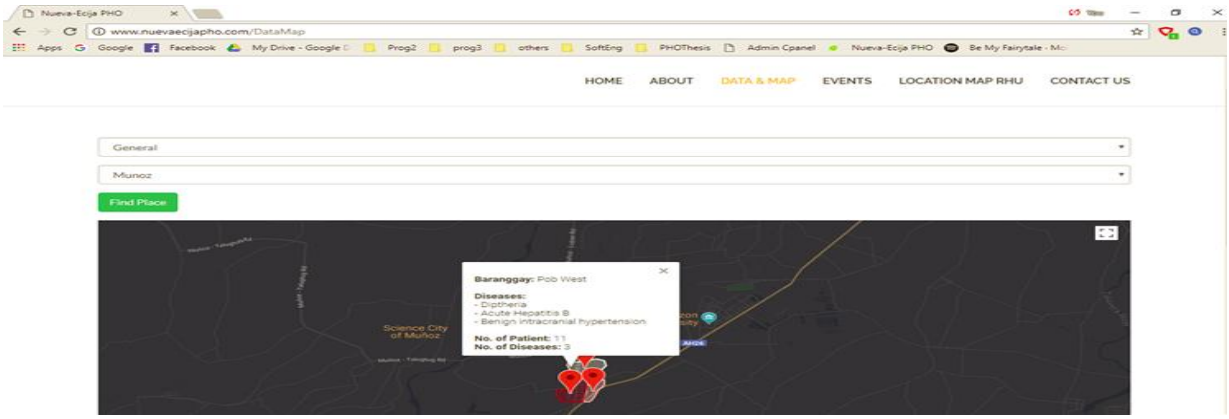


Figure 4. The Key Features of Web-based Application for Public End User

The information will be represented in the web-based application including the description of the organization, services offered, news and event, the data representation in table numbers of the total population of patients with different diseases that are monitored by the agency, charts and graphs of population per type of diseases reported and interactive maps per area of different disease [12, 13, 14] cases included in the study [10, 11, 17]. (See Fig. 3 and Fig. 4) For the mobile application, it will be used by the community-based health workers deployed by the Public Health Office in the Rural Health Unit per Municipality Health Office and City Health Office [8,9, 16]. The community-based health workers will input the electronic patient record received from the public health services of the unit in the said mobile application [1, 2]. (See Fig. 5)

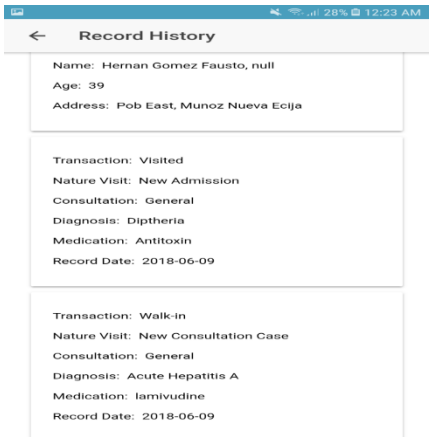
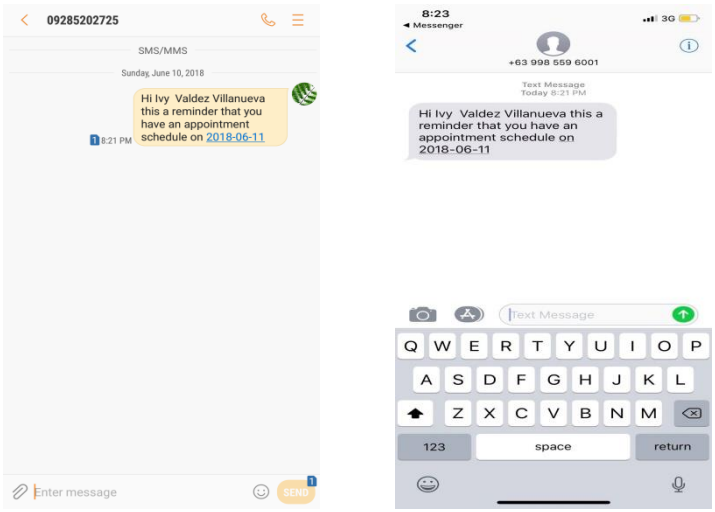


Figure 5. Patient Health Record History Interface

It can also manage the number of patients who will be attended by the assigned physician in the health center with the help of the functionality of setting an appointment schedule for the patient [6, 15].



Sender **Patient Received SMS Notification**

Figure 6. The SMS Follow-up Reminder Notification for the Patient with Schedule Appointment

The patients will then receive a text message as a reminder for follow- up consultations and treatment like vaccines needed to inject in the patient through the contact details given in the electronic patient's record. (See Fig. 6)

2.2.4 Develop Phase

The proposed health management system was constructed with the use of web-based application technology in the fourth phase of the agile development. Laravel PHP Framework was used for the web-based application to be maintained by the Public Health Office of Nueva Ecija. The mobile application was used by the community-based health workers while Mobile Ionic Framework was used utilized. This technology was used to create a mobile application for the version of Android mobile phone users. The MariaDB was used for the database engine and storage of the data was done through Cloud Infrastructure. Node JS was used to create API between Web-based Application and Mobile Application.

2.2.5 Release (Unit Testing) Phase

The fifth phase in the agile development process is composed of iterations to the first release. In the first iteration, it created a system based on the user requirements of the organization to be tested by the organization thru the testing stage. The follow-up iteration was made based on the comments and suggestions of the users from the first iteration. This was attained by choosing the stories that administered the building of the entire system.

The community-based health workers and public health provincial officials determined the stories to be selected in each iteration. The functional tests created by the community-based health workers and public health provincial officials were tested at the end of every iteration phase. Several activities occurred during this phase including additional testing and checking of the system's performance that was required before the system was deployed. New changes may still be found and the decision has to be made if they are included in the current release.

2.2.6 Track and Monitor (Acceptance Testing) Phase

Once the system has been released, it needs to be kept running smoothly. In this last phase, the tested system with the supplied data given by the customer rather than the mock-up test data was utilized. The acceptance test might show omissions and errors in the requirement definition of the system because the actual data of the system were different. Acceptance tests may also show complications of the requirements where the facility of the system was unacceptable to the need of the users.

2.3 Data Analysis

In taking the sample population needed for the study, the Raosoft Calculator and Stratified Random Sampling formula were used for computation in the percentage and numbers of the distribution per location for the figure of respondents of community health and public end -user. Familiarization of the population in the province was a big help to determine the appropriate sample size. The Raosoft Calculator was used to compute the total sample size for the Community Health Workers and Public End User. The stratified random sampling formula was then used for the distribution of the figure per location that was needed in the respondents of Community Health worker and Public End User.

$$\bar{y}_{st} = \sum_{i=1}^{I} W_i \bar{y}_i \qquad W_i = \frac{N_i}{N}$$

Fig 7. Stratified Random Sampling Formula

Where:

y_bar_st: mean number of total population

Stratum (i)

Ni: number of respondents in a location

N: total number of respondents

yi-bar: mean number of respondents per population per location

In Figure 7, the researchers made use of Stratified Random Sampling in determining the population size of the sample distribution in each location. In this sampling technique, all the respondents' responses were taken into view

and no part of the responses was discarded. With this, the proponent was able to get a better representation of the data.

The data for which the respondents have given their insights into the performance of the system were stratified. This means that the responses were grouped according to the role and privileges given to them. This gave an assurance that each subgroup within the population received the proper representation within the sample. The advantage of using the said technique is that it reduces selection bias. Community-based Health Workers for example are grouped separately from the I.T. Experts and Administrator Staff from the Provincial Health Office of Nueva Ecija because their role and access rights into the system will be deeper and thus, will have more responsibilities with the system.

The total population of Community-based Health Workers and Public End Users were based on the target places where the system will be initially implemented at Science City of Munoz, San Jose City, Gapan City, Municipality of Guimba and Talavera. To interpret the results of the survey questionnaire, the proponent employed the Likert Scale with 0.05 margin of error with the following formula (See Table 1):

$$WM = \frac{(ES*6) + (VS*5) + (SS*4) + (SD3) + (VD*2) + (ED*1)}{\text{Total Respondents}}$$

Where:

Rating = total result of the evaluation

VS =total number of respondents who answered Very Satisfied

S = total number of respondents who answered Satisfied

MS = total number of respondents who answered Moderately Satisfied

MD = total number of respondents who answered Moderately Dissatisfied

D = total number of respondents who answered Dissatisfied

VD = total number of respondents who answered Very Dissatisfied

DESCRIPTION	VALUE	CONVERSION
VS	6	5.18-6.00
S	5	4.35-5.17
MS	4	3.51-4.34
MD	3	2.67-3.50
D	2	1.83-2.66
VD	1	1.00-1.82

Table 1. The Likert Scale Conversion Table

3 Results And Discussion

3.1 Acceptance Testing Phase

Based on ISO/IEC 25010 standard for software quality, the results of the system evaluation with the designed survey questionnaires were answered by 166 Public End Users (Novo Ecijanos), 25 IT experts, 54 Community-based Health workers (Public Health Physician, Public Health Nurse and Public Health Midwife) and three (3) from Public Health Office of Nueva Ecija management employees particularly from the I.T Department and higher officials from Public Health Office of Nueva Ecija who were concerned with the proposed system. Hence, a total of 248 respondents served as the basis for the system assessment. (See Table 2)

CRITERIA	Rating N=248												Mean	Likert
	6	%	5	%	4	%	3	%	2	%	1	%		
Functional Suitability														
Functional Completeness	101	40.73	110	44.35	37	14.92	0	0.00	0	0.00	0	0.00	5.26	**VS**
Functional Correctness	114	45.97	101	40.73	33	13.31	0	0.00	0	0.00	0	0.00	5.33	**VS**
Functional Appropriateness	109	43.95	113	45.56	26	10.48	0	0.00	0	0.00	0	0.00	5.33	**VS**
General Weighted Mean based on Functional Suitability													**5.31**	**VS**
Performance Efficiency														
Time Behaviour	71	28.63	133	53.63	43	17.34	1	0.40	0	0.00	0	0.00	5.10	**S**
Resource Utilization	61	24.60	140	56.45	47	18.95	0	0.00	0	0.00	0	0.00	5.06	**S**

Capacity	83	33.47	102	41.13	58	23.39	5	2.02	0	0.00	0	0.00	5.06	**S**
General Weighted Mean based on Performance Efficiency													**5.07**	**S**
Compatibility														
Co-existence	89	35.89	99	39.92	60	24.19	0	0.00	0	0.00	0	0.00	5.12	**S**
Interoperability	122	49.19	73	29.44	52	20.97	1	0.40	0	0.00	0	0.00	5.27	**VS**
General Weighted Mean based on Compatibility													**5.20**	**VS**
Usability														
Appropriateness Recognizability	110	44.35	101	40.73	37	14.92	0	0.00	0	0.00	0	0.00	5.29	**VS**
Learnability	94	37.90	145	58.47	9	3.63	0	0.00	0	0.00	0	0.00	5.34	**VS**
Operability	105	42.34	135	54.44	8	3.23	0	0.00	0	0.00	0	0.00	5.39	**VS**
User Error Protection	116	46.77	111	44.76	21	8.47	0	0.00	0	0.00	0	0.00	5.38	**VS**
User Interface Aesthetics	117	47.18	114	45.97	16	6.45	1	0.40	0	0.00	0	0.00	5.40	**VS**
Accessibility	132	53.23	101	40.73	15	6.05	0	0.00	0	0.00	0	0.00	5.47	**VS**
General Weighted Mean based on Usability													**5.38**	**VS**
Reliability														
Maturity	101	40.73	103	41.53	44	17.74	0	0.00	0	0.00	0	0.00	5.23	**VS**
Availability	109	43.95	104	41.94	35	14.11	0	0.00	0	0.00	0	0.00	5.30	**VS**
Fault Tolerance	69	27.82	151	60.89	28	11.29	0	0.00	0	0.00	0	0.00	5.17	**S**
Recoverability	119	47.98	95	38.31	34	13.71	0	0.00	0	0.00	0	0.00	5.34	**VS**
General Weighted Mean based on Reliability													**5.26**	**VS**
Security														
Confidentiality	148	59.68	77	31.05	23	9.27	0	0.00	0	0.00	0	0.00	5.50	**VS**
Integrity	126	50.81	94	37.90	27	10.89	1	0.40	0	0.00	0	0.00	5.39	**VS**
General Weighted Mean based on Security													**5.45**	**VS**
Maintainability														
Modularity	117	47.18	107	43.15	24	9.68	0	0.00	0	0.00	0	0.00	5.38	**VS**
Reusability	99	39.92	114	45.97	35	14.11	0	0.00	0	0.00	0	0.00	5.26	**VS**
Analyzability	102	41.13	117	47.18	29	11.69	0	0.00	0	0.00	0	0.00	5.29	**VS**
Modifiability	98	39.52	96	38.71	54	21.77	0	0.00	0	0.00	0	0.00	5.18	**VS**
Testability	134	54.03	90	36.29	24	9.68	0	0.00	0	0.00	0	0.00	5.44	**VS**

General Weighted Mean based on Maintainability													**5.31**	**VS**
Portability														
Adaptability	94	37.90	117	47.18	37	14.92	0	0.00	0	0.00	0	0.00	5.23	**VS**
Instalability	92	37.10	114	45.97	42	16.94	0	0.00	0	0.00	0	0.00	5.20	**VS**
Replacability	105	42.34	108	43.55	36	14.52	0	0.00	0	0.00	0	0.00	5.30	**VS**
General Weighted Mean based on Portability													**5.24**	**VS**
General Weighted Mean:													**5.28**	**VS**

Table 2. The ISO/IEC 25010 standard for software quality with the Software Evaluation Result

Table 2 presents the system assessment in terms of functional suitability rated by 248 Community Health Workers, Public End Users, Provincial Health Office employees, and IT experts who took an interest as respondents in this study. All respondents rated all the characteristics of functional suitability as very satisfied with a general weighted mean of 5.31. Through the benefits obtained in the system, both groups of Provincial Health Office employees, IT experts, and Public End User respondents have rated the functional suitability of the system as very satisfied. With this, it can be observed that the groups of the Community Health Workers obtained a lower mean compared to the two groups. One of the possible reasons is that Public Users, Provincial Health Office employees and IT experts are more exposed to technologies and the researchers has observed that some of the Community Health Workers were not into the use of mobile applications during the beta testing implementation. Even if the Community Health Workers obtained a lower mean, the user acceptance under the functionality suitability was rated as very satisfied by the 248 total sample populations of respondents.

In addition, Table 2 shows the system assessment in terms of performance efficiency rated by 248 Community Health Workers, Public End Users, Provincial Health Office employees and IT experts who took an interest as respondents in this study. All respondents rated all the characteristics of performance efficiency as satisfied with a general weighted mean of 5.07. Based on the findings, it is evident that from the group of the Provincial Health Office employees and IT experts, the Public End Users rating is higher than the group of Community-based Health workers. This is because they are quite unaware of the specification of their mobile devices. The user acceptance under the performance efficiency was rated as satisfied by the 248 respondents.

Moreover, Table 2 illustrates the system assessment in terms of compatibility rated by 248 Community Health Workers, Public End Users, Provincial Health Office employees, and IT who participated in this study. Majority of the respondents rated the characteristics of Co-existence as satisfied while Interoperability as very satisfied. The compatibility was identified as very satisfied with a general weighted mean of 5.20. Both groups of respondents (Provincial Health Office employees and IT experts, Public End Users) rated the compatibility of the system to be extremely satisfied, while in the group of the Provincial Health Office employees and IT experts, the Public End Users rating is higher than the group of Community-based Health workers. This is because the Provincial Health Office employees and IT experts are more knowledgeable about how the compatibility issue affects the system. Compatibility was one of the major concerns of the IT and engineering experts regarding the system. The application will not work properly if the mobile operating system is not compatible. The user acceptance under compatibility was rated as extremely satisfied by the 248 respondents.

In Table 2, displays the system assessment in terms of usability rated by 248 Community Health Workers, Public End Users, Provincial Health Office employees and IT experts. Majority of them rated the characteristics of appropriateness recognizability, operability, user interface, learnability, user error protection and accessibility as very satisfied. The assessment of the system in terms of usability was very satisfied with a general weighted mean of 5.38. Both groups of respondents rated the usability of the system to be very satisfied, but the group of the Provincial Health Office employees and IT experts obtained a higher rating than the group of consumers. Based on the result, one of the possible reasons is that the Provincial Health Office employees and IT experts are more aware of the specified goal of the system which is to develop an application that can monitor the record management of the patient electronic medical records. The user acceptance under usability was rated as very satisfied by the 248 respondents.

In Table 2 also illustrates the system assessment in terms of reliability rated by 248 Community Health Workers, Public End Users, Provincial Health Office employees and IT experts as respondents in this study. Majority of the respondents rated the characteristics of fault tolerance as satisfied while maturity, availability and recoverability were rated as very satisfied. The reliability was identified as very satisfied with a general weighted mean of 5.26. The group of Provincial Health Office employees and IT experts' ratings were higher than the group of Community-based Health workers and Public End Users rating. This is because IT experts and engineers are more aware of the system capability and efficiency. The user acceptance under reliability was rated as very satisfied by the 248 respondents.

The system assessment in terms of security was rated by the 248 Community Health Workers, Public End Users, Provincial Health Office employees and IT experts as respondents in this study. Majority of the respondents rated the characteristics of confidentiality and integrity as very satisfied. The security was identified as very satisfied with a general weighted mean of 5.45. While both groups of respondents have rated the security of the system to be very satisfied, it can be observed that the rating of group of the Provincial Health Office employees and IT experts is very close to the rating of the group of Public End Users. This indicates that the system provides a dependable security to the user's information and health data. The user acceptance under security was rated as very satisfied by the 248 respondents.

Furthermore, Table 2, reveals the system assessment in terms of maintainability rated by the respondents in this study. Majority of the respondents rated all the characteristics of maintainability as very satisfied with a general weighted mean of 5.31. The group rating of the Provincial Health Office employees and IT experts was higher than the group rating of the Community-based Health workers and Public End Users, possibly because the Provincial Health Office employees and IT experts are more aware of the probability of the system's performance repair action with a given period of time. The user acceptance under maintainability was rated as very satisfied by the 248 respondents.

Table 2 also presented the system assessment in terms of portability rated by the 248 respondents in this study. Majority of the respondents rated all the characteristics of portability as very satisfied with a general weighted mean of 5.24. Hence, both groups of respondents have rated the portability of the system to be very satisfied, while the Provincial Health Office employees and IT experts group rating is higher than the group of Community-based Health workers and Public End Users. One of the possible reasons is that the IT experts and engineers experienced more responsive software's ability in transferring data from one device to another device. The user acceptance under portability was rated as very satisfied by the 248 respondents.

The user acceptance of the whole system with the total general weighted mean 5.28 was rated as very satisfied by the 248 respondents.

4 Conclusions

This study started with the idea of automating the patient record management and disease monitoring management of the Provincial Health Office of Nueva Ecija. It was proven as an effective means of storing and retrieving the patient's records with the proper security features integrated with the automated system ensuring integrity and security of the patient's records using services available online and ensuring the ready accessibility of data pertinent to patients' records of the Provincial Health Office of Nueva Ecija.

The mobile application which can be installed on Android-based mobile phones provides a convenient way of accessing the web of the Provincial Health Office of Nueva Ecija by the authorized users. A well-developed system can be accomplished through the collaborative effort of the developer and the stakeholders.

The study was convenient for it allowed Community-Health workers to monitor the number of disease cases happening in their location which was made possible by using a mobile application. It was found to be very convenient and user-friendly. The SMS notification worked as intended. It sends message notifications to the patients who have a follow-up check-up or scheduled vaccination set by the Community-Health workers. The main purpose of the message notification in reminding the patient was met.

The integration of the different technologies used in the system made it possible to accomplish all the objectives. Also, the study utilized the ISO/IEC 25010 as the standard testing software to test the quality and functionality of the system. It was effective as a testing standard because it guaranteed that the created system reached the level of expectations of the respondents. Because it was standardized, the ISO/IEC 25010 defines a well-known quality characteristic and serves as a basis for many quality management approaches. It will guarantee an error-free program and software efficiency.

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