

## An Electronic Medical Patient Form System

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**Abstract:** *Projects in public health usually involve large volumes of patients' medical information. Traditionally researchers were required to establish and maintain a database of patient information by manually entering data collected from each patient. Not only is this process tedious and time-consuming, but it greatly increases the likelihood of human errors. With the rapid advancement of technology, it is only a matter of time before this process becomes automated. A two-step electronic medical form system has been developed, in which medical questionnaires are presented to the patient electronically. Upon submitting the electronic form, the patient's answers are automatically translated into a text-based file. In the second-step, the information embedded in these files will be transmitted into a relational database through a web interface. To empower the usability and flexibility of this system, a graphic-user interface (GUI) is provided to create new electronic forms with a variety of question formats. The information stored in this database can be queried and viewed in tables through a simple user interface. With this system, the integrity and efficiency of data storage and organization in public health projects will be well improved.*

### I. Introduction

Data collection is the foundation of public health projects as it can provide a great deal of information to the medical society in effort to improve the lives of millions of people. In a land of freedom and individuality, variations such as genetics, education, family, growth environment, etc, between research subjects can complicate a research project. In order to draw conclusions that will most benefit society as a whole, researchers must survey as many individuals with unique background as possible to conduct a statistical analysis of planned research. It is for this reason that for some time now, most public health projects will require the research subjects to complete a series of forms, with total number of questions for each subject reaching well over the hundreds.

Traditional data collection methods have long ago become an antiquated way of handling such complicated sets of patient data. Traditional methods often involve presenting the research subject with paper forms, which they are required to complete by hand and return to an administrator. In an effort to catch up with the advancement of technology, the traditional method was expanded to provide electronic

storage of this collected data. However, administrators would still be required to manually enter the information. Storing data electronically allows easy access to desired information versus traditional methods of sorting through numerous sets of paper forms. Data can be retrieved and analyzed more rapidly than with traditional methods, however only as rapid as the administrator could enter information into the electronic storage.

The need for a system that fully automates data collection becomes apparent when considering the vast amount of complicated data collected by the myriad of public research projects that exist today. An automated, electronic, application which will collect information directly from the patient and translate this information into electronic storage where it can be immediately viewed by project administrators, will drastically improve the quality of research performed as the administrators will be given back the time they would have otherwise lost. The Medical Patient Form system has been designed to help public health projects to move into the 21<sup>st</sup> century with how they collect and handle patient data.

**The Test Group:**

The test group for the Medical Patient Form System is the New York State, Psychiatric Institute - affiliate of Columbia Presbyterian Medical Center. The NYS Psychiatric Institute, Columbia Presbyterian Medical Center is one of the premier research institutes studying Eating Disorders. As the patient begins this study there are multiple forms that must be complete completed. At various milestones throughout the study, the patient has to complete additional sets of forms. At the end of the day, all patient information collected on these forms must be entered into a database by an administrator.

As mentioned in the abstract of this paper, public research projects need a way to maintain and track patient information regarding the project. In an effort to prove the theory the project focuses on, the researchers must be able to back up their claims with empirical data. It is in the interest of the researchers to limit human error as much as possible in order to make their case stronger. It is this need that calls for an automated system that will cut out any middle work between the patient and the storage of their information.

**The System:**

The current procedure employed by the test group, as well as most public health facilities, is the traditional method of having the patients complete all forms in paper format. The administrators must manually enter the patients' responses into a database. This procedure comes at a price; it is not only cumbersome and time consuming but also gives room for entry errors in the sensitive research data.

The goal of the Medical Patient Form System is to automate the form process and allow the patients to complete the forms electronically and have this data electronically transferred into the master database thereby minimizing errors, and dramatically reducing the time spent by the administrator on entering the data.

It is important to note the technical limitations often experienced by a public health project. It is important to realize most public health projects are often limited in funding, space, and labor.

Due to this reason, the following obstacles are not uncommon:

1. The patient is to complete all required forms at the research facility.
2. The research facility is not, and cannot be, equipped with any type of network/internet connection.
3. Space in the research facility is limited.
4. There is physical separation between the research facility, and the location of the administrator's pc that actually have network connection.
5. The database server is housed behind a firewall, prohibiting public access.

With these limitations, the implementation of the requested system becomes more difficult. The largest complication arises from the fact that there is no possibility for internet connection from within the research facility. Since this is physically separate from the network that the database resides on, there is no possibility of a direct connection to the database. This leaves us with a standalone patient application that is designed to run locally on a computer/laptop. Due to space restrictions, this standalone web application will be hosted on a laptop that will be provided to the patient for completing the forms.

Since there can be no connection to the database from this laptop, the only option is to store information locally on the laptop. However, some complications arise. The administrators must have access to stored information from their location. There is also the consideration that a laptop can only store so much information before hard disk capacity and performance issues come into play. Therefore the conclusion is to have the laptop serve as a host for an intermediary database. The patient will enter the information electronically, and the web application will record all user input into temporary storage - in this case a text file. This text file cannot be queried, nor will it be sensible to the laymen's eye. This text file is designed simply as a transitional phase between collecting the information and having that information stored in the database. Therefore it becomes the responsibility of the administrator

to retrieve that text file from the laptop and transfer the information into the database.

Since the location of the administrator's pc is equipped with network connections, the administrator currently has access to the existing database. Therefore a separate web application has been designed to run from the administrator's pc. All remaining requirements of this project can be fulfilled with the administrator's application. This application provides the ability to migrate the retrieved text file into to the

## II. Relevance

A system such as the Medical Patient Form System can revolutionize the way public health projects collect and manage their data. This system meets the demands of simplifying the collection and maintenance tasks while giving the administrators back the time they lose to perform all the tasks manually.

As mentioned previously, the technical limitations of most public health projects has prohibited the development of the system into one large software system that can perform all necessary tasks. It is important to note that although the system has been developed as two separate subsystems, the gap between the two systems can easily be bridged in a less technically limited environment.

Searching for 'similar' types of systems proved to be a difficult task. There were not many instances of automated medical patient data processing found. However, there were some systems that are worth mentioning in comparing what most of the medical world is doing to reduce the amount of data entry and administrative involvement in the patient form process.

Most 'similar' systems are a single application *that works in a networked environment*. This is the key feature. While many of the systems claim 100% automation, this is all dependent on database connection, internet/network connection, etc. - Certain things that many public health projects are not privileged to.

database. This application will also provide the administrator with the means to query the database, edit information stored in the database, and create new forms to be used in the research study.

The overall goal is to remove the manual labor that exists in the current process. Due to the technical limitations, an entirely automated solution was not possible to implement. However, our project will reduce the manual labor involved severely, as well as the amount of human error.

A popular software system in Form Automation is offered by LexisNexis(<http://www.lexis-nexis.com/autoforms/>). However, this system is limited to official public legal documents. This software is powered by HotDocs which is a program similar to the PDF environment where users can type their answers directly onto the form. However, its' primary purpose is to relieve the time consuming and tedious task of manually completing forms yet the form must be printed and signed.

The data storage offered with the LexisNexis product is limited. There is no central database that can be queried as each user's information is kept in a separate file. The user information can only be retrieved from an 'answer file' to fill in fields in the electronic forms, after which they must still be printed and signed.

LexisNexis provides an very nice form generator with high user interaction. However since the documents are specialized to the legal industry the questions are canned, and customization is limited. The user can only select from the list of available questions and can only input custom information when the software system 'thinks' it needs more information.

Other systems, such as eFlow (<http://www.topimagesystems.com/asp/main.asp>) provide the ability of capturing data from any source and presenting it on a single platform.

Therefore it can capture data from paper forms via OCR scanning, from electronic forms, from files and from the Internet. This system provides similar database functionality as the Medical Patient Forms system in that it creates a collection of all relevant information and provides a means for viewing the collection. However, this system does not provide the means for actually collecting the data.

While the 'entering' the data is simpler than the traditional process, the manual labor factor is still there. This system does not provide the electronic or paper forms, as does the Medical Patient Form system. This system also does not provide an 'automated' data migration. The attempt of the Medical Patient Form System is to minimize human interaction to the greatest extent possible, and based on the research done to find similar systems it is the most successful. The most common system that could be found in some medical facilities are ones that only offer the convenience of saving the patient time spent filling forms out in the medical office. The facility publishes a website and from this website the patient can remotely download a copy of the required forms. The patient can then print out the form, manually complete it, and bring the completed form with them to the medical office.

### III. Methodology

The hardware system is comprised of several components: a database, a standalone laptop, and a networked PC.

MySQL is the database of choice because of a number of features. Most importantly since many public health projects are state funded, funding is limited. MySQL is part of the OpenSource project and the fact that it is free was a major attraction. Most public health projects foresee their research study growing, with hopes to incorporate additional studies into the application. A simple database like Microsoft Access is not capable of handling such robust requirements in any simple and easy to use manner. MySQL has proven to be simple to set up, administer and manipulate and the team felt that the design of the

Such an example of an effort to reduce time and convenience patients can be seen [http://www.arizonarms.com/arms-laboratory\\_forms.htm](http://www.arizonarms.com/arms-laboratory_forms.htm).

Many other systems offer OCR capabilities for scanning in patient forms. However, these systems, like eFlow do not provide the forms, and are only worth mentioning as they provide some sort of electronic storage. Patients must still complete paper forms and return the forms to administrators. The administrator must then scan in each form and manipulate the OCR software until it completely recognizes each entry. The accuracy of the OCR is only as good as the software being used, and the administrator still has to review each entry for validation and accuracy. Most OCR software will scan the form in and store the information as a PDF document for electronic viewing.

The lack of comparable systems demonstrates the great need of a system such as the Medical Patient Form System for use in public health projects. Accurate patient information and availability of that information when it's required is a must, yet there are few options for simplifying the process of providing it.

database can become much easier to understand than the current database.

A web application was decided as the best means of facing the obstacles while maintaining a level of user-friendliness. Since a web application can both run locally on a properly configured machine and provide an interface that is both familiar to the user and simple to use, it was the wise choice. Developing the system as a web application also affords a simpler upgrade to a fully integrated system upon the relief of the technical limitations presented.

There are two environments for which the application must be compatible. The first is a laptop that will be provided to the patient for

completing the forms. The second is workstation to be used by the administrator that is capable of connecting to the database server. In either case, the computer will have similar system requirements. Since the product is a web application each workstation must be configured as a web server. The environment of choice is a Window's based system configured with Apache as the web server. Again great consideration was given to Apache because it is part of the Open Source project as well; therefore it is a free web server. Apache is capable of handling the same, if not more, robust application that other web servers can handle. In fact, Apache is used to server over 65% of the website currently available on the internet.

The web application consists of HTML pages, and PHP pages and scripts. PHP was chosen as the preferred language because of its benefits and capabilities - there are very few limitations of what can be done with PHP. A fact that was also taken into consideration was that once this project was implemented, there were certain maintenance requirements to consider. It must be possible for teams to come to maintain the project, and it was a general overall opinion that PHP would be the easiest language to maintain.

Most public health projects currently have existing forms in paper format. For the test group, electronic versions of each form used in the study have been generated manually by the programmers. For future groups form generation can easily be handled by the Form Builder which will be discussed shortly.

Many research studies will track patients by a unique patient identification number which is confidentially associated with the patient's name. The traditional method for form processing requires the patient to repeat this information on each form. This can be come cumbersome and frustrating to the patient as well as the administrator entering the patient data into the database. Since each form requires the patient's name, and patient ID, an entry screen has been designed to accept that patient name and ID so that this information only has to be entered once.

After this information has been entered and the patient proceeds to complete each form these fields are automatically completed using the information input on the entry screen.

Many research studies require patient information at various intervals throughout the study's length of time. With the traditional methods the same nuisances and tediousness applies. This has also been considered in the development of the entry screen which is to be completed by an administrator. In addition to the patient's name and identification number, the administrator can now click a checkbox from the list of available forms to indicate which forms are required. The patient proceeds to fill out the first form, and as the patient completes each form, the system will automatically bring them to the next form in the selected group that needs to be completed.

There is no direct connection to a relational database from the patient computer. With most public health projects, the volume of data that needs to be stored can grow to proportionate sizes. The simplest means to implement the solution was to develop a PHP script which will take the user input and write the information to a text file. This text file will be stored temporarily on the laptop until it is retrieved by an administrator. Information is written to the text file separated by predetermined delimiters. Each delimiter separates an entry to be made into the database.

One issue with public health projects is to ensure that all required information is gathered, and that the patient completes all the required forms. In the traditional form process the patient is given a set of patient forms and upon completion these forms are returned to an administrator. However, it is quite unlikely that the administrator will enter the data into the data base immediately at that point and it is also unlikely that the administrator will validate the form responses. This severely limits the accuracy and completeness of the data which is required to reinforce the theory that the research study has set out to prove.

The patient will not be allowed to log off from their session until all required forms have been completed. If for some reason the patient disconnects the session prematurely and improperly, the patient will be able to revive the session and continue until all forms are completed. By entering the Session ID on the entry page, the patient can resume with the remaining forms and when the information is translated to the database it will be associated with the correct interval of the project.

A question arises when trying to automate the process of collecting confidential patient data for public health projects. If all patients are using the same PC to complete their forms, how can each patient's data be kept secure from prying eyes? In the medical industry, patient confidentiality is of utmost importance and is taken very seriously, as set forth in new HIPPA regulations. Violating such confidentiality is often punishable with high fines and/or imprisonment. Therefore certain measures have been taken to prevent patient information from being redisplayed once the form has been submitted.

After a patient submits the form they are automatically brought to the next form in the set. Once the set has been completed, the patient is asked to log off the system. If a patient were to leave the PC unattended, or return the PC without logging off, their information becomes vulnerable. Due to this reason, the "back" button on the internet browser has been disabled. If the patient were to walk off after completing a form and leave the PC unattended and someone attempted to view their data by hitting the "back" button, the session will expire, and the browser will display a "Warning: Page has expired" error message.

Another point of possible confidentiality breach is the text file output by the application once the form has been submitted. Locating this information that has been stored on the PC requires a bit of knowledge of where to begin looking. If the prying eyes were to manage realizing that the information is stored in a text file, and if they were able to locate the text file, it

is unfortunate for them that the information obtained in the text file will not be very legible.

The Form Management section of the system has been developed with the needs of growing public health projects in mind. While research studies often have a series of canned questions and responses, the ability to create new and highly customized forms on the fly is an attractive feature for those projects wishing to begin new studies or expand their current study. The Medical Patient Form System comes packaged with a Form Builder and Form Editor to provide any public health project a comforting level of flexibility in the administration of their study.

The form management tools runs on the administrator workstation which has network access to the relational database used to store all patient information. The Form Builder is a generic form generator that will allow administrators of the public health project create new forms as needed to improve or expand their study. The administrator can enter questions along with the possible answer choices for each question. As each question is completed, the administrator can add more questions of the same type, save their questions and generate the form, or edit the form in progress. As each new question is added to the form, a preliminary template of the form is displayed at the top of the screen so the administrator can view their work in progress.

Once the administrator has created all questions for the new form they can generate the form. The new form will automatically be added to the application. The form is created following the same database structure as the existing forms making integration simple. As the form is generated, the appropriate fields are populated in the database to store the form information and form questions and answers.

This new form is immediately available for use in the Patient Entry system that is installed on the administrator's workstation. Before transferring this form to the application on the standalone PC used by the patients, the administrator can go

back and edit the newly created form so that it more appropriately meets their needs.

The Form Editor provides the administrator with the ability to retrieve forms created with the Form Builder and make changes to its structure and content. Upon entering the Form Editor application, the administrator is present with a list of forms that can be edited. At this point the administrator can view the form, edit the form, or delete the form.

This level of flexibility is welcome in a research study environment where conditions may change that warrant new observations to be made. Much of the manual labor has been removed from this process as well. This will cut manual labor time by saving the administrator the time it would take to print the form, making Xerox copies and adding the new forms to the existing paper form packages.

Perhaps the most important feature of the system to public health projects is the ability to query the patient data. Due to the technical limitations of the environment, it will be necessary for the administrator to physically retrieve the text file that was created from the laptop and transport it

## IV. Results

As of current date, the product has not been implemented for use therefore we do not have solid information regarding the usefulness of the product in the intended environment. As of current date the use of the system has been limited to testing.

To summarize, this product will prove to be a very useful tool for public health projects. The goal of the system was to have an automated process that would take out the currently required human legwork. Within this application there are different features available based on whether or not the user is a patient or an administrator of the research study. The following section describes the use of the system from each user group's perspective.

to the administrator's networked PC via removable media such as a floppy disk.

Selecting the option to transfer data to the database provides instant transfer of the data to the relational database server. Progress is displayed to the administrator ensuring the success of the transfer, and as each file is transferred it is deleted. Deleting the text file is comparable to shredding the paper forms once the patient has completed them and their information has been entered into the database. This reduces the risk of prying eyes viewing the information, again adhering to the concern with patient confidentiality.

Since data is transferred to the database more rapidly using this system, it can also be queried more rapidly. The administrator is given the option to query the database by Patient ID, Form Name, and date entered. By having immediate access to patient data, public health project administrators can have more immediate feedback on research progress and can make adaptations in the study as they see fit. This kind of accessibility to the data is important to public health projects in that progress can be displayed more frequently, which can prove to be crucial in defending reasons for funding.

**The patient:** After an administrator has launched the application and entered the patient's Name, patient ID number, session ID number, and required forms, the patient will be presented with the laptop. The patient fills out the required electronic forms and returns the laptop to the administrator.

As the Internet Age is rapidly advancing, most patients will be relieved at the loss of the pen and paper process. While the system might prove to be frustrating to some of the less computer savvy patients it will be a convenience for most others. In the even that the patient is adamant about not using a computer, the option of the paper forms still exists.

**The administrator:** The administrator can point the application to the text file retrieved from the laptop and transfer patient data into the main database. There are also features available to query the main database with a flexible query tool, and view and/or edit information as required. And lastly the administrator is provided with a feature that will allow them to create new forms as needed.

As competition for funding becomes fiercer, public health projects have to ensure that they provide accurate data to back up their claims. By automating the patient information collection system, human error is reduced by approximately

## V. Conclusion

Due to the technical limitations of many public health project facilities, the process of arriving at a solution was not a simple and seamless task. There is still some human interaction required, although the amount has been drastically reduced. The amount of human error has also been minimized as the data entry portion of the process has been eliminated.

Provided the environment remains bound by the existing limitations, this system will be a successful implementation as is. Instructions for its use will be well documented, and its users will be properly trained. The systems as a whole have been designed to be extremely user friendly, and an attempt has been made to automate even the most menial tasks so as to make the system work more to the users' advantage. By using the system, public health project administrators will be restored more time to focus on the research study at hand. Due to these limitations there is

95%. Public health projects will feel more secure in presenting evidence that has been collected directly from and retrieved directly from the patients. Another important fact to mention is that by automating the patient information entry system, public health projects can cut unnecessary costs of pen and paper supply, and not to mention improve the environment by producing less waste.

While the system has yet to be integrated at the test group's location, the team has been testing the application throughout the course of the development process. The application is proving itself to be very useful and very well designed with the users in mind.

still a small amount of labor required of the administrator but in comparison to the existing system, this amount of labor is menial.

If the technical limitations are alleviated then a series of new opportunities for an upgrade will arise. With as little as an internet connection, the application can easily be upgraded to allow the information input by the users to be stored directly to the database. There will be no need for the laptop to serve as an intermediate database, and no need for the creation of the text file and migration of the text file to the database. This would further increase the automation of the system as the administrators will have immediate access to patient input, and will gain back the time it takes to transfer the information stored into the text file. With as little as an internet connection, the public health project will be well on its way to having a truly 100% automated form processing system.

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