Translating Effective Paper-based Disease Management into Electronic Medical Systems

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***Abstract*—We developed an innovative approach to computerize and integrate a previously-validated but paper-based asthma disease management program into an electronic medical systems. Asthma is the leading chronic disease of children and currently affects about 6.2 million (8.5%) children in the United States. National Asthma Education and Prevention Program (NAEPP) Guidelines recommend a multimodal chronic care approach. However, both the 1997 and 2007 NAEPP guidelines have not been widely adopted by primary care clinicians. Easy Breathing©is a cost-effective, asthma management program that has improved the quality of pediatric and adult asthma care, but uses paper and pencil dictations that have not been translated to an electronic format. When practices transition to an electronic health record (EHR), a paper-based program becomes cumbersome for clinicians to use in their new clinical workflow. Although integrating Easy Breathing into practice-based EHRs is most desirable, it is expensive and technically difficult as EHRs are proprietary and are the greatest barriers to continued use of the validated paper-based program. In this paper, we describe an informatics and software development model that translates Easy Breathing into a web-based system. This system is ready for integration into payer-provider web portals, such as the portals of Medicare/Medicaid vendors or private insurance companies. The availability of such a software system will allow clinicians to test the feasibility of using non-practice-based electronic systems that cut across different EHRs to integrate effective paper-based disease programs. Our preliminary evaluation with a few healthcare professionals demonstrates that the resulting software is a streamlined and effective tool. Future clinical studies will be needed for system evaluation at the point of patient care.**

I. Introduction

Asthma is a serious public health problem that affects almost 25 million people (7.8% of the population in 2008) in the US [1]. Worldwide, 300 million people suffer from asthma with 250,000 annual deaths attributable to the disease [2]. Asthma costs are rising as asthma prevalence and hospital use increase [3], [4]. Use of guidelines by primary care clinicians could improve the process and management of asthma care. National guidelines for asthma diagnosis and management were released beginning in 1991 and have undergone multiple iterations as new science and new therapeutic approaches have emerged [5]. Despite the release of these guidelines for the management of asthma and many other diseases, relatively few primary care practitioners have integrated guidelines into patient care. The meaningful use and integration of practice-based EHRs has the potential to nationally transform quality measurement and quality improvement, but to date, it has not achieved this potential [6], [7].

Easy Breathing is an asthma management program that is based on the 2007 National Asthma Education and Prevention Program (NAEPP) Expert Panel Report-3 (EPR-3) Guidelines. It is currently being used in 100 pediatric practices in Connecticut. The program consists of 5 validated tools (a Survey that aids clinicians in making a diagnosis of asthma, a tool that assists clinicians in determining asthma severity, an Asthma Treatment Selection Guide that guides clinicians in choosing appropriate therapy and a field-tested, culturally appropriate Asthma Treatment Plan that is given to every patient with asthma). In addition, Easy Breathing uses two validated tools to assess asthma control (the Asthma Control Test™ and the childhood Asthma Control Test. Children with asthma, enrolled in Easy Breathing (32,596 in CT through 12/31/2013), have experienced a 35% reduction in asthma hospitalizations, a 31% decrease in emergence department visits [8], [9], and a 19% decrease in urgent care visits with a positive return on investment to Medicaid of $3.58/child with asthma/year [10]. The program has been replicated in eight other states.

When practices have gone paperless with the adoption of electronic health records (EHRs), many have regrettably stopped or reduced their use of Easy Breathing as paper-based programs become cumbersome to use in their new clinical workflow. Integrating Easy Breathing into practice-based EHRs is necessary, but expensive and technically difficult as each EHR is proprietary and is the single greatest barrier to continued use and dissemination of the program. Every one of the approximately 400 commercial EHRs is proprietary and integration must be managed for each EHR one at a time. Engaging EHR companies in this process is time consuming, technically difficult, and extremely expensive. In addition, even when integrated, yearly maintenance is required as drugs for asthma enter and leave the market and as new guidelines for asthma become available. Currently, the only option is an EHR-specific work-around which is incomplete, labor intensive and adds significant additional effort for the practice.

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In this paper, we describe an approach that separates the creation of an asthma clinical decision support (CDS) system from the programming setting of any specific EHRs. We have created a web-based system that computerizes the full set of guidance provided by Easy Breathing and this web system is designed to be ready for integration into payer-provider portals which are commonly available, especially for Medicare/Medicaid vendors. These payer-provider portals could be used by primary care practitioners (PCPs) to report their services for expense reimbursement. When their reports suggest a deviation from asthma guidelines, the payer can use the portal to direct and advise the practitioner via the CDS system which is designed to enhance asthma care. Hence, as a very important design purpose, our system should also easily interact with practice-based EHRs by automatic reporting with the portable document format (PDF) and should require a minimum number of entries to be re-entered from our system to the EHRs. We focus on the discussion of our software design that is used to operationalize the knowledge and information flow in Easy Breathing, and that makes the system ready for integration into payer-provider portals and easy for interaction with practice-based EHRs.

II. Related Works

Current electronic systems for asthma management do not provide the same streamlined, convenient way as Easy Breathing to diagnose asthma and determine asthma severity. Most importantly, they do not generate a patient friendly, patient-understood Asthma Treatment Plan.

Existing electronic systems for asthma care range from small tools for patient self-care, such as the Asthma Tracker, to integrated systems that are designed to assist clinicians, such as UCAN-MAP [11], [12], Stop Asthma [13], [14] and a few EHR-based CDS systems [15]–[19]. Computerized asthma decision support systems delivered through an EHR can be helpful in adhering to asthma guidelines [16]–[20]. Most of these decision support systems are limited, however, to one or two aspects of the asthma guidelines.

A recently completed study reported that an EHR-based asthma CDS system which provides alerts and reminders defined using the NAEPP EPR-3 guidelines and created by a panel of institutional experts, improved clinician compliance with the guidelines, but with mixed performance when results in urban practices were compared to results from suburban practices [21]. The system was implemented in the EHR using an existing decision support framework for childhood immunization [22]. The combination of the utilized components was not validated for its effectiveness before going into an EHR. The EHR implementation via the framework for a different disease may not be optimal.

A comprehensive CDS system [16], [17] was developed by a multidisciplinary team at Yale University based on the NAEPP guidelines. This system was not targeted for use by PCPs and was only evaluated in a pediatric pulmonary clinic. The limited adoption is probably partly due to the complexity of the system which may require a rather significant workflow change by pulmonologists relative to the net benefits it can provide. This system, however, represents a novel effort to use a computer-mediated process to automatically convert guidelines that are written in vague and underspecified language into unambiguous rules that permit direct operationalization [17]. Nevertheless, the extremely vague language about medication suggestions in the guidelines hinders an exclusively computer-based inference system to consolidate concrete and precise treatment plans in contrast to the clear knowledge accumulated by specialists in their years of operationalizing the guidelines, such as in Easy Breathing.

It is hence essential and beneficial to create an easy-to-use, streamlined electronic CDS system that is based on Easy Breathing's validated decision support tools with a full range of guideline guidance. If disease management programs such as Easy Breathing can be integrated into the new workflow with EHRs, this will pioneer a model to translate other successful paper-based disease management programs into EHR workflows. Using payer-provider portals to integrate Easy Breathing into EHRs also opens up a new use of provider portals to convey patient specific data that facilitates real-time information exchange between payers and providers.

III. System Design

In this section, we describe the design and the core algorithms of our software system which we have named *eEasyBreathing*. The core algorithms include those for assessing the severity and level of control for asthma patients, and the algorithms for planning treatments.

A. Algorithm flowcharts

Figure 1 shows the information flow between the core components of *eEasyBreathing*. The system first prompts the clinician to query if the patient has been previously diagnosed with asthma and is receiving any asthma medications, or the system looks up the historical records if any in the system. If the patient is currently not being treated with asthma medications and has not been previously diagnosed with asthma, the system will prompt the doctor to complete a survey called the *Easy Breathing Survey*, which asks questions about the presence of asthma symptoms, family history of asthma or allergies and identifies common asthma triggers. Positive responses to specific questions are suggestive of asthma [23]. If at this step the clinician confirms that the patient has asthma, the system will flow to the *Assessment* page to determine asthma severity. Otherwise, if the patient has previously been diagnosed with asthma, the asthma control test (ACT) or childhood ACT will be automatically prompted on the *Assessment* page according to the patient's age. Based on patient responses to ACT, the system will calculate the score and based upon pre-established cut off points will determine if asthma control is adequate. If not, the system will suggest adjusting the patient's asthma medications and perhaps the patient's asthma severity. More details for the *Assessment* page and its algorithms will be given in Section III-B. For a new diagnosis, the system prompts the clinician to ask about symptom frequency and suggests

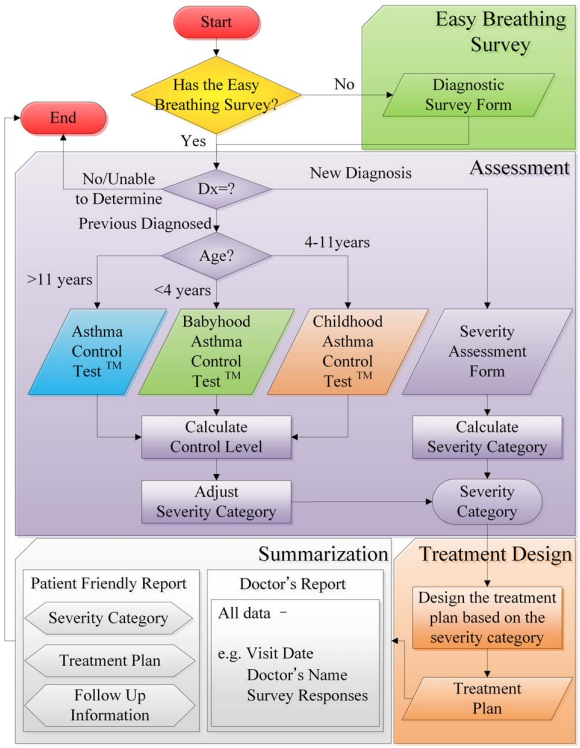

Fig. 1. The information flow in our system

based upon asthma guidelines an asthma severity which the clinician confirms and changes. Once the severity category is determined, appropriate medications, specific to that severity are displayed on the *Medication* page for the clinician to choose. The details of the *Medication* page are given in Section III-C. Once the clinician selects a medication regimen for the patient, a patient-friendly report (Asthma Treatment Plan) and a clinician's PDF report will be generated for download in the *Summary* page. The Asthma Treatment Plan is given to the patient and contains patient-understandable treatment instructions. The clinician's report comprises all data recorded for the specific visit and is ready to import into the clinician's EHR system. Further, the database entries in our system can be uploaded to the payer-provider portal if the portal allows this data transmission.

B. Asthma assessment

On the *Assessment* page, the system will check the diagnostic status of the patient. If the patient's diagnosis is *No Asthma* or *Unable to Determine* based on the responses to the Easy Breathing Survey as shown in Figure 1, the system will return to the *Start* position which is the initial page when a clinician logs in and shows a list of patients in the practice. Otherwise, if asthma is newly diagnosed, the system will flow to the severity assessment form where 5 pre-defined questions will be asked. The asthma severity will be determined based on the responses to these questions, and shown on the screen as a chosen radio button from one of the categories of "intermittent", "mild persistent", "moderate persistent" and "severe persistent". If asthma is previously diagnosed with a severity category, the ACT or childhood ACT will be shown on the *Assessment* page. Patients older than 12 years of age will complete the ACT [24]. Patients from 4 to 12 years of age will complete the childhood ACT. Patients younger than 4 years of age will answer a series of 5 questions designed by Easy Breathing [25]. The question responses determine the level of asthma control as one of the three categories "good", "marginal" or "inadequate". For *marginal* or *inadequate* control, the system will prompt the clinician to change the patient's therapy and perhaps even increase the severity category. The adjusted severity will be used to determine a guideline-appropriate treatment plan in the *Medication* page.

As an example, for a patient who is at 3 years of age, according to the guidelines, the asthma severity is examined by both impairment and risk. The impairment domain is assessed by the patient's /caregiver's recall of any asthmatic symptoms in the previous 4 weeks. The level of severity is determined to the most severe category in which any feature/symptom occurs, or in other words, in the answers to the 5 pre-defined questions in the severity assessment form. All the responses that a patient or a medical assistant responds to our system will be automatically loaded to the backbone database that is part of the system, and is described in Section IV-B.

C. Treatment design

Based on the (adjusted) asthma severity category and the age of the patient, a list of guideline-appropriate medications will be displayed. The treatment plan typically includes daily, sick and emergency plans. The 2007 NAEPP guideline suggests 6 steps in designing the daily medications based on the severity category. In our database, the medications are organized into groups of equal potency specified by Easy Breathing. Then in database tables, a field is used to specify usage instructions of these medications. For a not-well-controlled patient, even if the clinician decides to regulate the patient's symptoms in the same severity category, medications of higher potency (higher dosage) within the same severity group may be suggested to better control the symptoms.

As an example, for the severity category of "mild persistent", the treatment plan contains 3 components: daily treatment, sick treatment and an emergency plan. In daily treatment, one and only one medication from one of the two controller categories (an inhaled corticosteroid or a leukotriene modifier) and a rescue medication can be chosen from the selection boxes in the *Medication* page. Note that there are medications in different groups of potency including a "really low dose", and a "higher albeit still low dose" of the inhaled corticosteroid. The appropriate dosage is automatically recommended by the system according to the clinician confirmed asthma severity and Easy Breathing guidance. However, whether to prescribe the really low dose or the higher but low dose is determined by the clinician. The system enforces the selections that satisfy the treatment design rules of Easy

Breathing. For instance, if a clinician misses to choose a medication from the inhaled corticosteroid group, the system will not allow him/her to go to the next *Summary* page and rather prompt an alert. The system will also dismiss the choice of choosing two or more medications in one category of medication.

IV. System Implementation

This section is dedicated to a more comprehensive description of how the system is implemented, including the modularity software architecture and the database design. We also use an example of payer-provider portal, the one at Community Health Network of Connecticut (CHNCT), the Medicaid vendor in Connecticut, to illustrate how our system can be integrated into payer-provider portals.

A. Modularity software architecture

The Model-View-Controller (MVC) principle is a software engineering architecture which has been widely used as an approach for developing systems that deal with more than one view of the same data. MVC helps to decouple the underlying business logic from the user interface. It makes the system easy to manage as it enables the developers to develop, test and maintain the three main components: models, view and controller, independently. We used the widely accepted open source frameworks in the information technology industry, including Struts, Spring and Hibernate frameworks to implement the principle of MVC as shown in Figure 2.

In the MVC principle, controller layer processes the request and alters the models or the views appropriately. It communicates between the model layer and the view layer by listening to the request and instantiating the model classes which are used to alter the view as required. The controller layer defines the behavior of the application.

The view layer manages the visual representation of the data. It can be seen as a wrapper around the data models in the model layer, and is capable of displaying a subset of the data that is encapsulated in a model. The view layer allows us to change the layout of the web-based system without altering any back-end data. It helps us to develop a friendly interface with clinicians to incorporate their feedbacks into our system.

The model layer manages and operates on the data of the application. It contains the business logic to access and update the data, and receives requests from the controller layer and sends responses to the view layer. The model layer allows us to easily modify the medication list according to new guidelines. When a new treatment guideline is released, the only required change to our system lies in the model layer and database. For example, the data table containing the list of medications will need to be updated to adhere to the new guideline. We have created a function named getListofMedication(*table_name*) in the model layer that uses data from this data table. Linking this function to the updated database table will enable the new guideline-appropriate medications for treatment recommendation. No other changes will be needed at any other layers. It leads to a minimum amount of revision efforts to update the system.

The controller layer controls the relationship between functions in the view layer and the model layer. The view that a model function should use and/or the model which a view should return its selections to, both depend on the management in the controller layer.

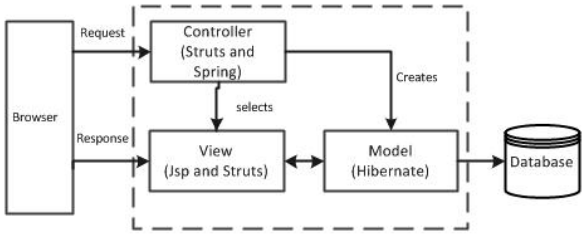

Fig. 2. The implementation of model-view-controller

The view layer is implemented using function modules based on Struts (v2.5) [26] and Java server pages (JSP v2.0). Reusable components are managed by Apache tiles (v2.2), and JavaScript (v1.8.2) is used to program in the view layer, for instance, to manage HTML pages.

The controller layer is implemented based on Struts (v2.5) and Spring Framework (V 3.0.5) [27]. Requests are processed by the controller servlets of the Struts and delegates to the service layer which is implemented using Spring. The service layer instantiates the required classes in the model layer and is also responsible for reusing the classes. The database connection is also managed by the service layer.

Hibernate (V 3.6.1) [28] is the object-relational mapping tool in the model layer. Main components of this layer include Data Access Objects (DAOs) and Data Objects (DOs). DAOs manage the communication with the data sources such as a database. They separate the data source implementation from the controller layer and the view layer. They also manage the queries to the database in order to obtain data using Hibernate Query Language (HQL). DOs are java objects which represent the database tables. They are used by DAOs to retrieve data from the database. Hibernate makes the application independent of the underlying database vendor.

B. Database design

We used the relational data schema to model data for the website. My-SQL is the database vendor we used to develop this project, and can be changed to any other database easily due to the use of Hibernate. A variety of tables are designed to store different types of data and to manage the relations among the data. Main tables include tables containing medications and their types based on the guidelines, tables containing all the pre-defined questions and their possible answers and tables consisting of the login information for the clinicians and the practices. Figure 3 shows an example of a few relational tables used in our application.

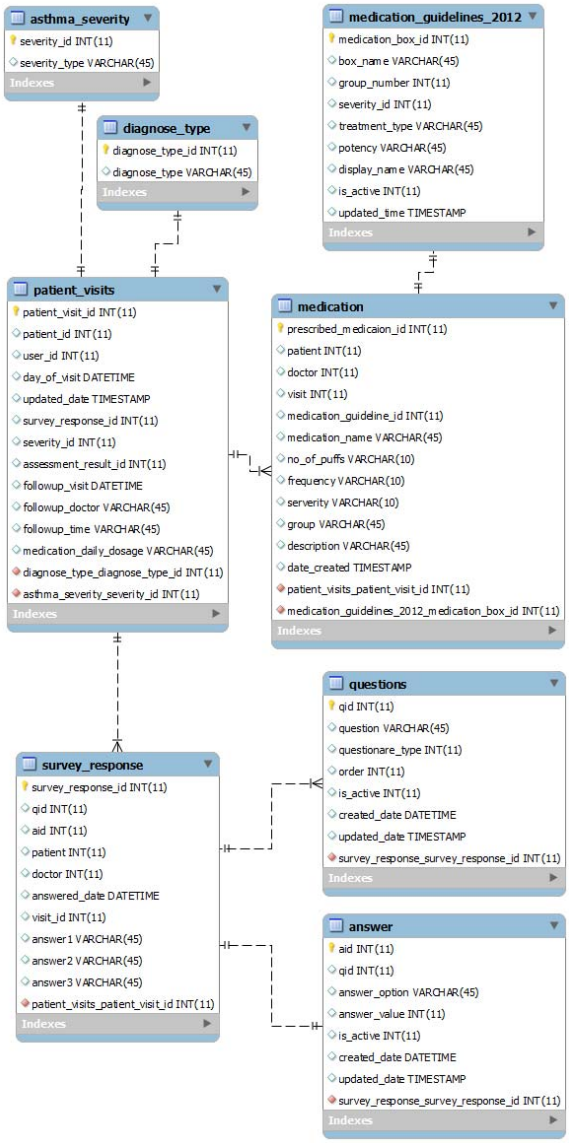

Fig. 3. Sample tables in the database

The names of medications together with their proper dosage and frequency, and the severity categories for which the medications are appropriate are all stored in the *medication* table. This table is linked to the severity table by the *severity* identifier in order to help the grouping of the medications based on the asthma severity. It also connects to the *medication_type* table which specifies if the medication is an inhaled corticosteroids (ICS), short acting beta agonists (SABA) or long acting beta agonists (LABA) etc. The *Medication_Guidelines_year* table will link the drugs from the *medication* to the right selection boxes in the view layer. Information on new drugs can be loaded from the payer-provider portal and re-formated via a java-based bridge.

Pre-defined questions are stored in the *questions* table and their possible answers are stored in the *answer* table. Foreign key references are used to link these two tables. The Status field will help to find the active questions in the table. As an example, if a question becomes unnecessary in a later guideline, it does not need to be removed from the table. Instead, we set the question to an inactive status in the table, which makes it possible to recover the system with early-version questions. Both tables are linked to the *survey_response* table.

The *survey_response* table is used to store the patient's responses to the questions defined in the *questions* table at a specific visit. Through the answer identifier, this table is also linked to the *answer* table. Date on which the question was answered is also stored in this table. The *patient_visits* table is connected to the *survey_response* table so the patient's responses at previous visits can be retrieved from this table by the patient identifier. The *patient_visits* table saves other details of the patient visit, such as visit dates. Records of any previous visits, if stored in our system, can be retrieved using this table. The *patient_visits* table also relates to the *patient_visits_medication* table (not in Figure 3) and *diagnose_type* table to retrieve the diagnosis and medications determined at a specific visit.

Clinician registration and *login* information are all stored in the login table which is not shown in Figure 3. Each clinician must be assigned to a practice whose information is pre-populated by an "Administrator". The system accesses the *login* table to authenticate and authorize the clinician login. The role and permission tables are devised to store the roles of the different users, including "practicing clinician", "practicing administrator", "administrator", and "nurse" etc. and to control the access levels of different roles. For example, a practicing clinician is allowed to set up a table of patient records within his/her practice. The "administrator" has a full access to the different accounts and may have capability of helping users to recover their data.

C. Communication with the payer-provider portal

We have collaborated with the original Easy Breathing team at the Connecticut Children's Medical Center (CCMC) and the CHNCT, the Medicaid vendor in Connecticut to test whether our system can be integrated into CHNCT's web portal. Figure 4 shows the presumed clinical model with which our system will be used in CHNCT's operation. This model has been designed to evaluate the feasibility of using our system in the portal and also the new use of the portal for gathering patient specific information rather than providers' summary data for the reimbursement purpose only.

Medicaid-insured children with asthma in a specific practice has been identified by the *Easy Breathing* team and by the payer-provider portal through Medicaid claims data. Prior asthma history about the identified children is pre-populated into the *eEasyBreathing* system and the web server is placed at a secured site of CCMC. When a child with asthma is seen in the care office, the office staff will enter the portal, and link to the *eEasyBreathing* application. The application will open and

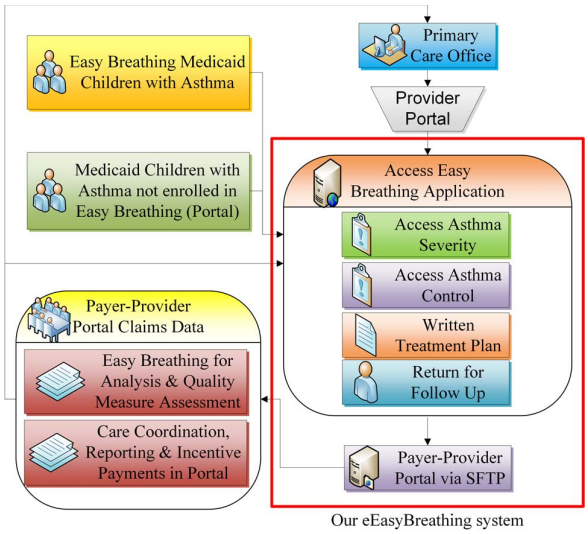

Fig. 4. The clinical model for the use of the *eEasyBreathing* system and the payer-provider portal. The highlighted box shows the *eEasyBreathing* system that is discussed in this paper.

information about the child's asthma and access to the Easy Breathing CDS tools will be provided after the child's family's accepting the consent for electronic access to the information. The snapshot of the child's asthma will be recorded by the application including any information captured through the application regarding to the asthma severity, asthma control level, and written treatment plan on file. Upon completion of the visit and the CDS tools, the data will be synchronized with the payer-provider portal claim data and stored on the *eEasy-Breathing* database for the future use of the clinician/office and for the subsequent analysis of the provider portal.

In order to accomplish the data exchange between the payer-provider portal and the *eEasyBreathing* application, we established a java-based bridge to exchange and synchronize the data. The bridge reads the data from the My-SQL database through the Java Database Connectivity (JDBC) driver. The format of the data will be revised by the bridge to be compatible with the data of the portal. Then the formatted data will be sent via the safe file transfer protocol (SFTP) as depicted in Figure 4. A new data table named *maps* is generated by the bridge and stored in the backbone My-SQL database of *eEasyBreathing*. All data related to the patients, visits, medications, and providers will be mapped from the portal to the My-SQL database and vice versa with an unique identifier in the *maps* table. This table can avoid the synchronizing issue and reduce the size of the exchanging dataset. The bridge imports the data from the portal and transfers them into the format of the *eEasyBreathing* application. We have obtained a set of de-identified claim data for a specific practice from the *Easy Breathing* team at CCMC, and validated the java bridge by converting data between the claim-data format and the data format of *eEasyBreathing*.

V. System Evaluation

This section discusses some important implementation characteristics that were assessed in our evaluation process. In particular, we paid attention to the ease-of-use nature of the web system and the advantages of this electronic system (*eEasyBreathing*) over the existing paper-based product.

In a series of meetings with two experts from the Easy Breathing team at CCMC and three healthcare professionals at CHNCT, the application of *eEasyBreathing* was presented and evaluated. The two Easy Breathing experts examined if the application correctly reflected the logic and streamline of Easy Breathing. The three experts from the CHNCT helped to evaluate and refine how the application should interact with CHNCT's Medicare/Medicaid portal.

A. Portability and security

This system is built on top of tools which are compliant with Java specifications and therefore portable across all compatible application servers that run Java. Currently the system is deployed on the Tomcat server as an web application server. The web pages are built with selection boxes and radio buttons to be used with tablets and desktop/laptop computers. The radio buttons and the selection boxes are efficient in that the clinicians can just click the buttons or the specific elements in the screen to choose. For each visit, the clinicians only need to click 10 times on average on the screen. Although the system offers assessment and prompt appropriate list of medications, it allows clinicians to select a different choice if he/she feels more comfortable with it, and nevertheless the system will indicate the discrepancy between his/her choice and the guideline recommendation on the webpage using a highlighted message in red fonts.

Even though the developed system is not intended to store patient data in the same manner as an EHR, we provide multiple security means to protect the data stored at clinicians' accounts through a secured login. The application can be accessed only through a secured login with password protection and role-based access control. The "administrator" has authority to re-generate a random key when a user forgets his/her password. The *Login* module will authenticate the username and password and the accessibility is controlled by the roles of the users. Patient information is tagged to the practice where the patient receives medical care, and is shared among the clinicians within the practice as suggested by the Easy Breathing team and the CHNCT team. The patient information is not shared with any clinicians from different practices.

The current evaluation system is deployed in an academic setting which does not hold actual patient data. The final product will be deployed in payer-provider portals where the actual patient data are stored and managed under the auspices of an appropriate institutional review board (IRB).

Due to the model-view-controller design, as pointed out in Section IV-A, the experts have assessed that the system has enough flexibility to incorporate new evidence-based guidelines without dramatical re-programming of the entire system.

The MVC design also helps the technical support team to make changes easily since all the logical components are modularized.

B. Advantages of eEasyBreathing

The design of *eEasyBreathing* has been modified in several rounds according to the suggestions given by the experts in our evaluation team, which has incorporated many features aimed at an easy adoption in the EHR-based clinical workflow. Although this system has not yet been deployed into real clinical encounters, we anticipate the computerized system is able to extend the same efficacy because the paper-based Easy Breathing program has established evidence on its effectiveness for asthma care management [8], [29].

Additionally, the computerized system possesses a few advantages over the validated paper product as follows.

- *eEasyBreathing* could further simplify the workflow of a provider than the paper-based product. For example, the electronic Assessment page assists providers in selecting the appropriate form of the Asthma Control Test (or the form for severity assessment) and calculates the level of asthma control (or severity category) automatically and immediately after the form is answered. In the paper product, providers have to manually make sure that the right forms are used and numbers are calculated correctly for each patient visit. Another example is that the providers no longer need to read and completely understand the treatment selection guide in Easy Breathing because the guidance is embedded in the electronic system by the background logic computation.
- Besides the ease-of-use feature, the electronic system can also be more accurate than the paper-based product because it avoids many potential mistakes in a visit. For instance, the system alerts the clinician to any medication combination that violates the guidelines that have been incorporated into the system's logic modules. Asthma medications are unambiguously partitioned into groups according to their potencies and are organized in such groups in the backend database. These groups are shown in the front end user interface, which facilitates providers to quickly find an appropriate combination of medications to formulate a treatment plan.
- The most useful and convenient feature of our system that the experts in our evaluation team acclaimed is the functionality of automatically creating a patient friendly report. This report includes the patient's asthma severity category, and the daily, sick and emergency treatment plans in a patient-understood format together with date and time of a follow-up appointment. This automation eliminates handwriting such a report, avoids potential mistakes in the report and assures readability. *eEasyBreathing* automatically creates this report in a portable document format which is easier to store and transfer than hardcopy paper sheets. The system also creates a report summarizing the entire visit for the provider to use.

Based on the evaluation of these healthcare professionals, *eEasyBreathing* can be a streamlined and effective tool for use in the electronic workflow of primary care providers. In addition, the web-based system is publicly accessible at http://www.labhealthinfo.uconn.edu/EasyBreathing/.

VI. Conclusion

We have designed an electronic version of an effective and efficient decision support system that can enhance asthma patient care at the primary care physician's offices. This system can be integrated into any payer-provider portal to deliver patient-specific information and clinical decision support, which facilitates care coordination and assists clinicians in enhancing adherence to asthma guidelines. This system is a web-based decision support system that integrates intelligent computer technology and complex guideline guidance together with the knowledge needed for implementing the guidelines. It is able to collect guideline-suggested diagnostic measures, automatically assess asthmatic severity and control categories based on collected measures as well as provide guideline-appropriate medication regimen.

Our system pioneers a model to integrate a disease program into the EHR, and a new use of the payer-provider portal for timely exchange of patient information between providers and payers. This model could be rapidly scaled up for use by all practices that provide care for Medicaid-insured children with Asthma if it were integrated into a payer-provider portal. This system aims to improve clinician's adherence to the latest NAEPP guidelines during their clinical encounters with patients. Our current evaluation strategy through collaborating with a few medical professionals allows us to examine the correctness and effectiveness of the system design and the feasibility of using such a system in payer-provider portals. Future clinical trials will be needed to accurately assess how effectively the system can be integrated into a practice's EHR-based clinical workflow, and the efficacy of using this electronic model in managing asthma care. We plan to also augment our system with additional modules to facilitate use by other payers. Furthermore, developing the smartphone-based app is another research direction in the future.

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