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Contents

1. Introduction

This report documents a comparative analysis of CareWeb, a web-based clinical patient record system developed specifically for use by clinicians and clinical support staff at the University of Michigan Health Service (UHMS).

The analysis starts with an overview of CareWeb. Next, a literature survey on patient electronic record systems is presented to give an idea about the state of the art in this area. The findings of the comparative analysis, along with an overview of the methodologies and criteria used are given in the third section of the report. The particular systems used for comparison are the Organ Transplant Information System (OTIS) in use at the UHMS, VistA/Computerized Patient Record System (CPRS) in use by the Veterans Health Administration (VA), and MedicWare, a commercial electronic medical record system. The last section of the report summarizes the findings of our comparative analysis, and makes conclusions about how well CareWeb compares to other products in the market.

1.1. Overview of CareWeb

CareWeb is a web-interface to the Clinical Data Repository (CDR), which contains electronic medical records of patients. CareWeb pulls together almost "real-time" lab, radiology, registration, medical records, cardiology, neurology, and other data and makes it available to UMHS clinical personnel for the care of their patients. While CareWeb does not allow the modification of information drawn from the CDR and other sources, the system allows for information like doctors' notes, immunization records and medication lists to be added to a patient's record. It also provides a means to sign documents digitally to speed up the patient care process. The system is only available on the UHMS intranet and requires user and password logins from authorized people to access.

2. Literature Review

The last few decades have witnessed increasing awareness and interest in the adoption of information technology tools in health care settings. However, widespread use of such tools is yet to be realized both in hospitals and small clinical practices. Berner et. al have examined computer use in clinical settings in two broad time periods, 1960-1980 and 1980-present, with the goal of scrutinizing possible reasons behind the slow adoption of computer-supported tools such as the electronic medical record (EMR), and pinpointing recent changes in both the computer industry and medical profession that may enable widespread adoption in the future. They argue that although barriers to acceptance such as technology immaturity, health administrator focus on

financial systems, application "unfriendliness," and physician resistance still persist, changes in increased computer literacy in the general population, as well as changes in government policies and increased support for clinical computing, suggest that widespread adoption may be observed in the next decade [1].

In 1991, a now widely cited Institute of Medicine report titled “The Computer-based Patient Record: An essential technology for health care” was published in book format. The revised edition made available in 1997, was crucial in discussing key aspects in EMR use and implementation: defining health care needs, the users of patient records, the available technology and research necessary to meet users’ needs, and necessary legal and social policies for implementation. However, despite early government initiatives, only a few private sector organizations showed interest in the large-scale implementation of electronic health records [1]. The Kaiser Health System was among the few. In a recent qualitative study to examine users' attitudes to implementation of an electronic medical record system in Kaiser Permanente Hawaii, Scott et. al found that software design problems increased resistance to adoption, the system reduced physicians' productivity - particularly during the initial implementation period,- and the system required clarification of clinical roles and responsibilities [11].

In their study on a comparison between paper vs. electronic medical records in general pediatrics, Roukema et al have found OpenSDE, a generic structured data entry application promising for the support of physician data entry [10]. They state that implementation of EMR systems promises significant advances in patient care, because such systems enhance readability, availability, and data quality [10]. Although transitioning to EMR from paper charts has been slow, the EMR holds potential to increase the quality of care and efficiency in medical practice. Helm and Hansen propose the following list of core functions for the EMR [6]:

1. Health information and data: Patients’ diagnoses, allergies, and laboratory test results

2. Results management: New and past test results by all clinicians involved in treating a patient

3. Order management: Medications, tests and other services

4. Decision support: Electronic alerts and reminders to improve compliance with best practices, ensure preventative practices, identify possible drug interactions, and facilitate diagnoses and treatments

5. Electronic communication and connectivity: Secure and readily accessible communication among clinicians and patients

6. Patient support: Tools offering patients access to their medical records, interactive education, and the ability to do home monitoring and self-testing

7. Administrative processes: Tools, including scheduling systems, that improve administrative efficiencies and patient service

Among potential benefits of electronic health record systems, Sujansky also counts computer-generated patient reports for preventative care (e.g. mammography due dates, cholesterol

screenings), identification of patients taking medications that have been recalled or for which monitoring procedures have changed, alerting systems that notify clinicians when laboratory results indicate adverse conditions in a patient that require prompt attention, computerized practice guidelines that help clinicians plan diagnostic and treatment strategies in accordance with selected guidelines, and drug-monitoring programs that identify contraindications based on drug-drug interactions and therapeutic overlap with existing medications [13]. Although these potential benefits do promise higher quality in medical care and have been demonstrated in research settings, again very few exist in routine clinical settings [13]. Sujansky states that a major reason for this is the absence or inappropriate representation of the primary medical record in a machine readable form [13]. It is for this reason, and for increasing usefulness and usability for EMR users, that such systems need to be evaluated and improved for functionality, usability, and aesthetics.

Considering the potential benefits, the move towards more widespread adoption of EMRs, and existing alternatives in EMR systems, we would like to undertake a comparative evaluation of CareWeb with three potential alternatives. Before we move onto our findings, we review research evaluating existing electronic medical records and experimental systems, as this work offers insight into future directions for CareWeb and similar systems.

2.1. Future Directions for Electronic Medical Records

Several researchers note the need for interchangeable and transportable electronic medical records, as the benefits of digitizing the record are only as large as the system in which it can be used [2, 4, 7]. This is a challenge echoed in our interviews with CareWeb users: the system can be convenient, but when they need to access information generated outside of the University Hospital System, they must first locate it, have it sent to them, and then import it into CareWeb using more traditional means. Even within the Michigan health system, separate records are maintained in OTIS and CareWeb, and figuring out which system contains needed information can be a time consuming and frustrating process. Eichelberg at al's work may help illuminate a path for standardizing and integrating the records across the different systems, but this review is ultimately Euro-centric and finds that none of the reviewed standards is particularly promising [4]. Bossen offers a less technical discussion aimed at outlining some high level design decisions for electronic health records, including review of a prototype for a department of internal medicine that identified several shortcomings for use in clinical work [2]. Many of these shortcomings are shared with CareWeb.

Hristidis et al describe a more promising approach for exchanging electronic medical records [7]. They first recognize many of the same challenges as Bossen, primarily that patients are reluctant to share full medical histories even with their caregivers and that institutions are reluctant to share the records they maintain because of real and perceived legal restraints such as HIPAA and because owning the records gives them a competitive advantage. The authors argue that the value of some sharing, if properly designed, outweighs the benefits of balkanized set of medical records, and proceed to describe a flexible system that would meet the various stakeholders' demands. The need for standardization, and design of such a standard, will likely be an important area for future consideration across the field as well as for CareWeb's developers and users.

Several other authors examine new technologies and how their use in electronic medical information systems may improve integration with caregivers' workflows. Skov and Høegh create a prototype of a context-aware mobile system, running on PDAs, called MobileWard [12]. This

system adapts its display as the user changes locations: in the reception area, an appointment list is displayed; in the corridor, a list of current visitors, primary conditions, and room conditions is shown; and in the patient's room a chart and detailed patient information is available for display. All of this information is currently available in CareWeb but requires users to locate a computer and then navigate to the appropriate section, something users report to be fairly time consuming compared to how long they view each feature. Mobile access with context awareness may mitigate some of these problems. While reporting some promising findings, Skov and Høegh also describe many ways in which the mobile device becomes a concern or barrier in the patient-caregiver interaction. These concerns are consistent with some of the reasons doctors and nurses told us they prefer not to use the in-room computers to access CareWeb during patient visits, and some are worsened by the mobile (PDA) platform while others are reduced.

In another context-awareness study, Mendonça et al consider the linkage of patient data to literature retrieval [8]. In their system, information from a patient's electronic record is used to augment a caregiver's query terms to help find relevant results. The authors ran three experimental groups: one in which results did not use the clinical data; one in which other doctors (who had access to the clinical records) ranked the results, and one in which the results were ranked automatically according to the clinical record. Not surprisingly, the results ranked by other doctors were rated the best, but both sets of results ranked based on the data in the electronic record were rated significantly better than the unranked results. One could imagine this specific design as a future extension for CareWeb. Additionally, such use of electronic records to augment other tasks may suggest other future uses for the CareWeb data.

Munkvold, Ellingsen, and Koskvik analyze a electronic medical record system deployed in a Norwegian hospital [9]. They sought to quantify reported reductions in redundancy and improved patient handover times. Their measurements, however, found that despite these reported benefits, the electronic records actually decreased caregivers' productivity. Such findings are not inconsistent with larger trends in CSCW that find that increased IT investment often results in productivity decreases. During our interviews with CareWeb users, many have reported similar increases in redundancy, but also have anecdotally described ways in which CareWeb both takes more of their time and saves them time. Learning from this Norwegian study, we suggest that steps be taken to quantitatively measure the time and redundancy impacts of CareWeb use.

One of the causes both Munkvold et al and our team have found for increased redundancy is an increase in formal documentation. That is, while CareWeb reduced the total number of official documents required, the centralized nature of the system as well as limited access to computer necessitates that users create more handwritten, temporary, informal notes to assist their own memory. Work by Hardstone et al explores another facet of this informality in electronic medical records; specifically, communication is different than documentation [5]. They find that this distinction is not well understood by designers of electronic medical record systems, and that this is a major barrier to better integration with caregivers' workflow. Work by Hardstone et al, Munkvold et al, and our team suggests that CareWeb could offer an improved user experience that does more to augment users' productivity if it were to find a way to better support informal interactions and notes.

3. Comparative Analysis

In this section we present our comparative analysis by first discussing our methodology, second using a functionality matrix to compare the features, and last, outlining our findings.

3.1. Methodology

In comparative analysis of interfaces, detailed research can be done on various aspects such as usability, functionality and the aesthetics of the visualization. In this comparative report, we specifically look at the overall functionality and aesthetics of CareWeb (we will analyze the usability separately in a future report).

CareWeb has several features such as document management, patient record lookup, scheduling, and personal notes. For comparisons, we focused on three areas: supported environments, system-level features and patient record features. Supported environments analysis considers the resources needed to run electronic record systems like CareWeb. System-level features analysis considers the top-level functionalities provided by these products. Lastly, patient record features analysis looks at the available information rendered by the interface.

We identified competitive products through the Internet, local hospital and personal contacts in other hospitals. Seven candidates were initially identified. Based on the service provided and usage, four products, including CareWeb, were selected to be evaluated. Among the selected products, two are used concurrently in the UMHS and the other two are used in other hospitals. OTIS is the interface used exclusively in the organ transplant department at UMHS. VistA is used by over 160 VA hospitals in the states. MedicWare is a commercial electronic medical record software vendor, which provides both web-based and desktop software clients solutions.

3.2. Functionality Matrix

	CareWeb	Organ Transplant Information System (OTIS)	VistA / Computerized Patient Record System (CPRS)	MedicWare
System Environment				
Web-based	Yes	Yes	Online option available	Online option available
Open-source	No	No	Yes	No
Specialized by Department?	No	Yes	Yes	Yes
- If Yes, which?	--	Transplant clinics	All specialties	Primary Care
System-level Features				
Payment processing	No	No	No	Yes
Scheduling	View only	View only	View/enter	View/enter
Patient reminders	No	No	Yes	Yes
Clinical Physician Order Entry (CPOE)	No	No	Yes	No
Evidence-based recommendations	No	No	No	Yes
Document creation, editing, and signing	Yes	Yes	Yes	Yes
Patient lists	Yes	No	Yes	Yes
Patient Record Features				

	CareWeb	Organ Transplant Information System (OTIS)	VistA / Computerized Patient Record System (CPRS)	MedicWare
Demographics	Yes	Yes	Yes	Yes
Patient record flags	No	Yes	Yes	No
Document templates	No	No	Yes	Yes
Problem summary list	Yes	Yes	Yes	Yes
Immunization status	Yes	Yes	Yes	Yes
Medical image results	Yes	Yes	Yes	Yes
Scanned document support	Yes	Yes	Yes	Yes
Lab results	Yes	Yes	Yes	Yes
Vital signs	Yes	Yes	Yes	Yes
Vitals and lab results graphing	No	No	Yes	Yes

3.3. Detailed Findings

In our evaluation, we compare CareWeb to OTIS, VistA, and MedicWare in terms of usefulness to the end user and aesthetic sensibilities.

All four applications handle security differently. CareWeb and OTIS are both web solutions that work using secure connections off site. However, any CareWeb user has access to all CareWeb features, whereas OTIS has 12 different roles in which various functions are exposed depending on job title (e.g. surgeon, nurse, social worker, financial advisor). CareWeb, OTIS, and VistA do not prevent users from accessing any particular patient record, but instead have audit trails that may be reviewed at the end of the day or when wrongdoing is investigated to deter unauthorized access. Meanwhile, physician offices with MedicWare EMR have to maintain a server unless they purchase the online subscription service. Since each practice will have a smaller number of users, the vendor does not include audit trails in its product specifications. All four solutions are HIPAA-compliant, though only VistA and MedicWare claim to use HL7, a common health standard, to interface with ancillary systems.

At its core, CareWeb is web interface to the general UMHS patient record. Other UMHS systems include:

- EWT, an appointment scheduling program (though viewing appointments can occur in CareWeb)
- Computerized Physician Order Entry from Eclipsys (for ordering lab results)
- OTIS, a supplemental record system for the transplant clinic, which we are evaluating as well

VistA, a large suite of applications from the Veterans Hospital Administration, serves as an umbrella for many of the system-level features described in the functionality matrix. The VA Hospital System is completely computerized, from scheduling a patient to reminding patients of preventative care exams to claiming reimbursement for a service. One application, the

Computerized Patient Record System (CPRS), can be compared to CareWeb as a electronic medical record. MedicWare, on the other hand, is a system that is geared towards private practices. Other systems have support for evidence-based decision support for clinicians, but none of these systems have that level of sophistication.

Documents are the central feature of many of these systems, CareWeb in particular. CareWeb consists of free-text documents. A clinician dictates or types one document per patient encounter, and receives notifications in his or her inbox to sign a document afterwards. Many clinicians review the recent documents in particular prior to seeing a patient, so they must be able to retrieve them. CPRS documents are explained in the document templates in the Patient Record Features.

3.4. Patient Record Features

All systems we studied provided basic patient record features, such as document and lab results viewing; however, the quality of the solution for each system varied. This section will describe the various ways in which the key patient features varied and how these differences affect workflow in clinics. For the following color tables, green is represents good support for the feature, yellow, acceptable support for the feature and red, poor support for the given feature.

3.4.1. Demographics

	CareWeb	OTIS	VistA	MedicWare
Usefulness				
Aesthetics				

CareWeb and OTIS both draw basic demographic information from the CDR; OTIS, however, contains additional contact information in order to successfully reach a patient in case an organ is found for that patient. A kidney transplant nurse recounted that she finds OTIS contact information more “accurate,” when in fact it is the case that there are multiple entries for emergency contacts. In CareWeb, this extra information would be superfluous. Visually, the information is organized more clearly in OTIS than it is in CareWeb, where Demographic information is intermingled with visit information.

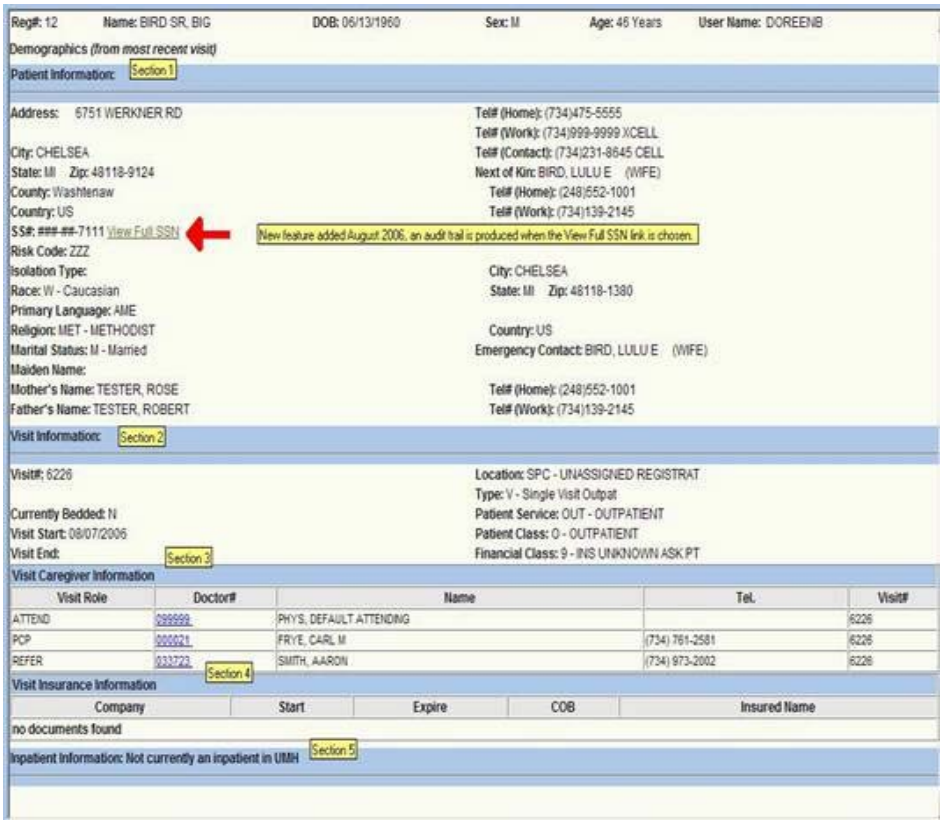

Figure 1 CareWeb demographic screen

In VistA's Computerized Patient Record System (CPRS) module, the patient's demographics must be selected from the View menu. The software displays a detailed demographics popup as shown in Figure X in plain text. Its usefulness to the provider spans the patient's regular demographic information as well as the patient's status and location in the inpatient ward or clinic.

Figure 2 VistA demographic screen

MedicWare, meanwhile, separates address and demographics by definition, into two separate tabs. Clinicians and staff interested in contacting a patient but needing demographic information have to switch between these screens. Aesthetically, the "Import" and "Capture" image features serves to humanize the patient record, in addition to allowing the caregiver to put a face to a name.

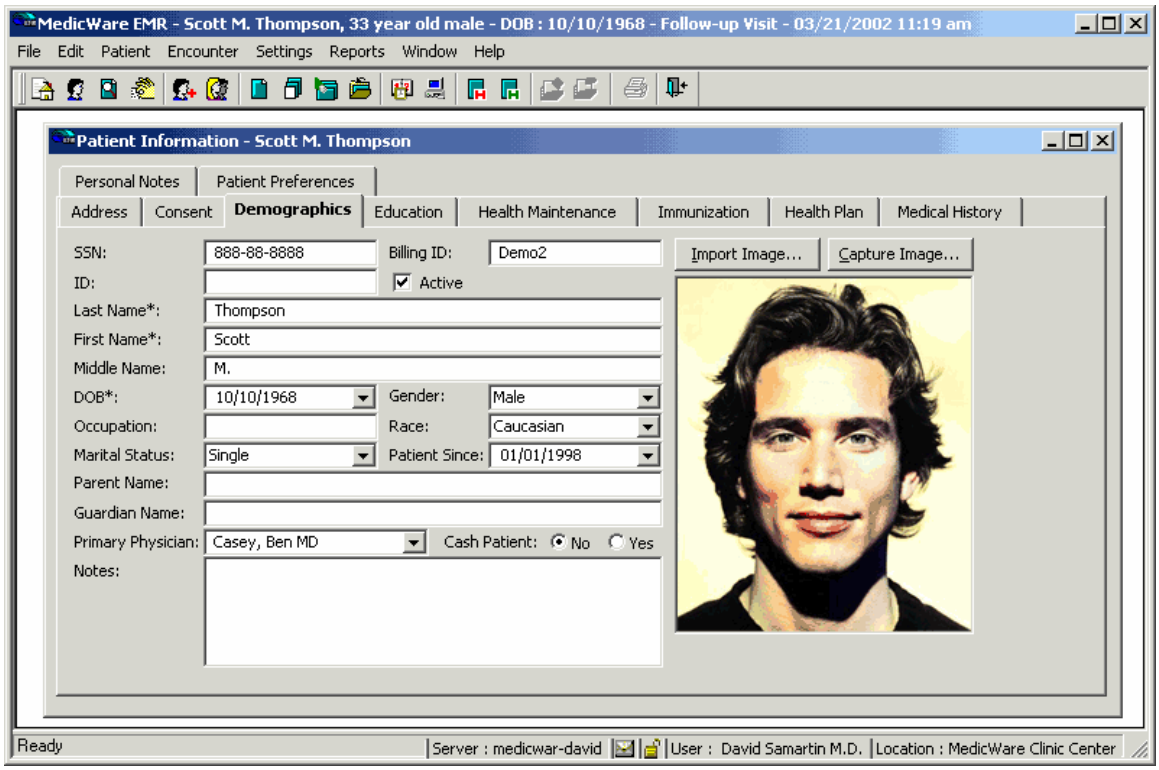

Figure 3 MedicWare patient demographic

3.4.2. Record Flagging

	CareWeb	OTIS	VistA	MedicWare
Usefulness				
Aesthetics				

CareWeb does not support flagging of its free-text notes to indicate a particular noteworthy diagnosis or event. OTIS supports flagging as well as adding a clinician task to a temporary "Issue List." Thus, any transplant clinician qualified to address the issue for the patient can sign on and do so. The Issue List page is current being redesigned for usability. VistA's CPRS allows flagging, though how the flagged record appears to the user is unclear. MedicWare's target audience of smaller practices may not find flagging patients as intuitive, and thus MedicWare does not offer such a feature.

3.4.3. Document Templates

	CareWeb	OTIS	VistA	MedicWare
Usefulness				
Aesthetics				

Many CareWeb users who create documents lament the repetitive nature of entering headings for certain types of notes and the variety of ways that authors choose to structure their documents. CareWeb does not have templates for document creation. Users enter document content into one large free-text field that cannot be marked up. However, OTIS has transplant-specific notes in addition to the free-text notes drawn from the CareWeb system. These specific notes are generated through HTML form fields, so the content is constrained somewhat but the whole note is then saved as free-text in the CDR.

VistA's CPRS offers powerful template document functionality, where pre-existing and shared templates are available in the explorer menu on the left and where users can create their own templates with "Patient Data Objects." Patient Data Objects include vital signs like blood pressure as well as demographics. While the interface itself is the notable Windows gray, the aesthetics of the VA's GUI do not affect the usage of this feature, according to one enthusiastic VA clinician.

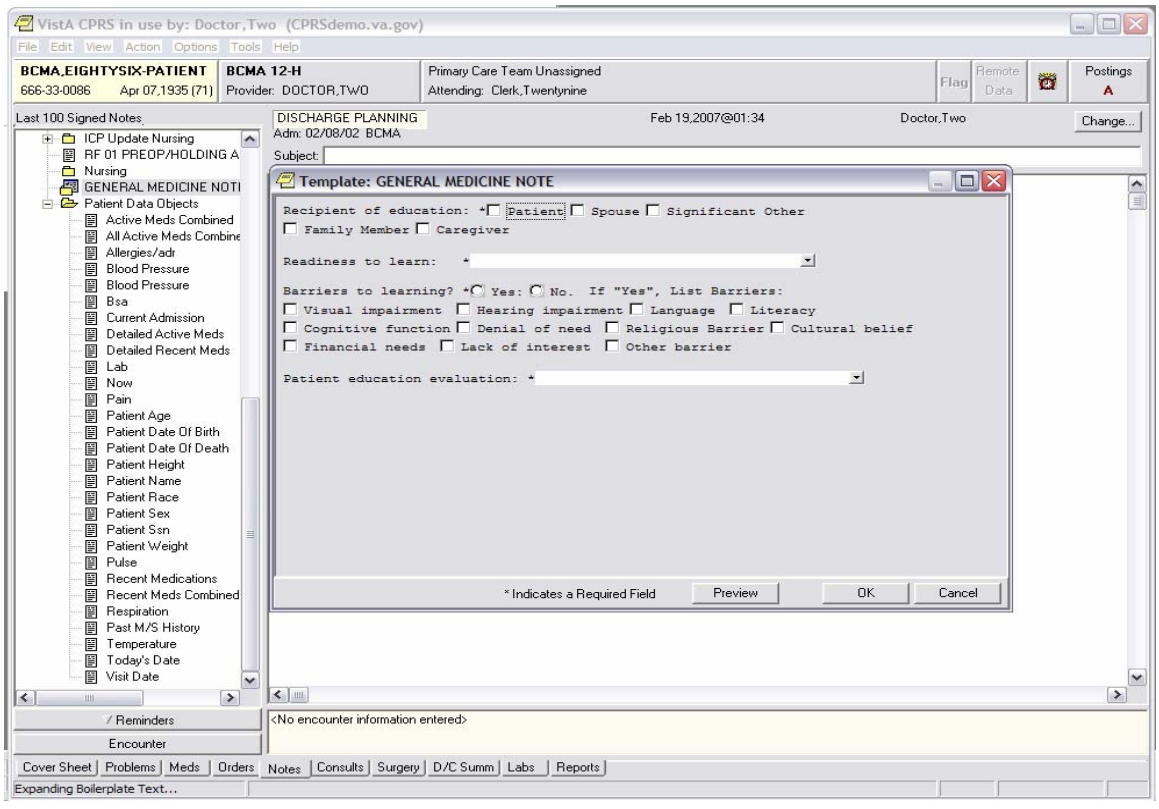

Figure 4 Vista document templates

MedicWare's Encounter tab separates out basic patient visit information from medical information in the progress notes tab. The Encounter form contains fields such as physician name, visit type, billing status, and comments. Meanwhile, the Progress Notes (figure 6) contain the detailed

information gathered during the visit about the chief complaint, demographic information, and medical history. The CC/HPI screenshot (figure 7) shows the functionality for selecting detailed notes elements and filling out values in a template format. Lacking interviews with actual MedicWare users, we find it difficult to assess this form-based approach for encounters and detailed notes, considering that so much medical history is entered under the various tabs, including "Exam." Physicians may take more time entering information in forms, but retrieval may be easier with these features. Aesthetically, using separate screens does manage to keep the screen real estate less cluttered, but physicians would have to switch between the screens.

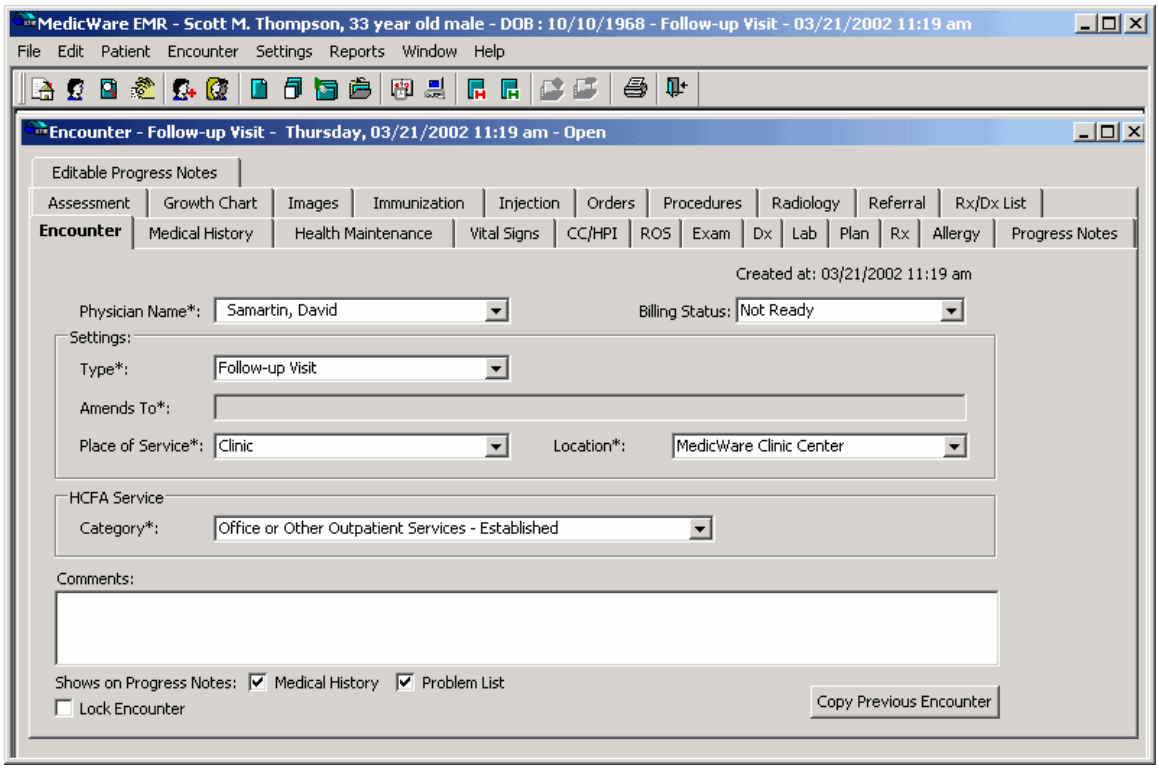

Figure 5 MedicWare templating screen

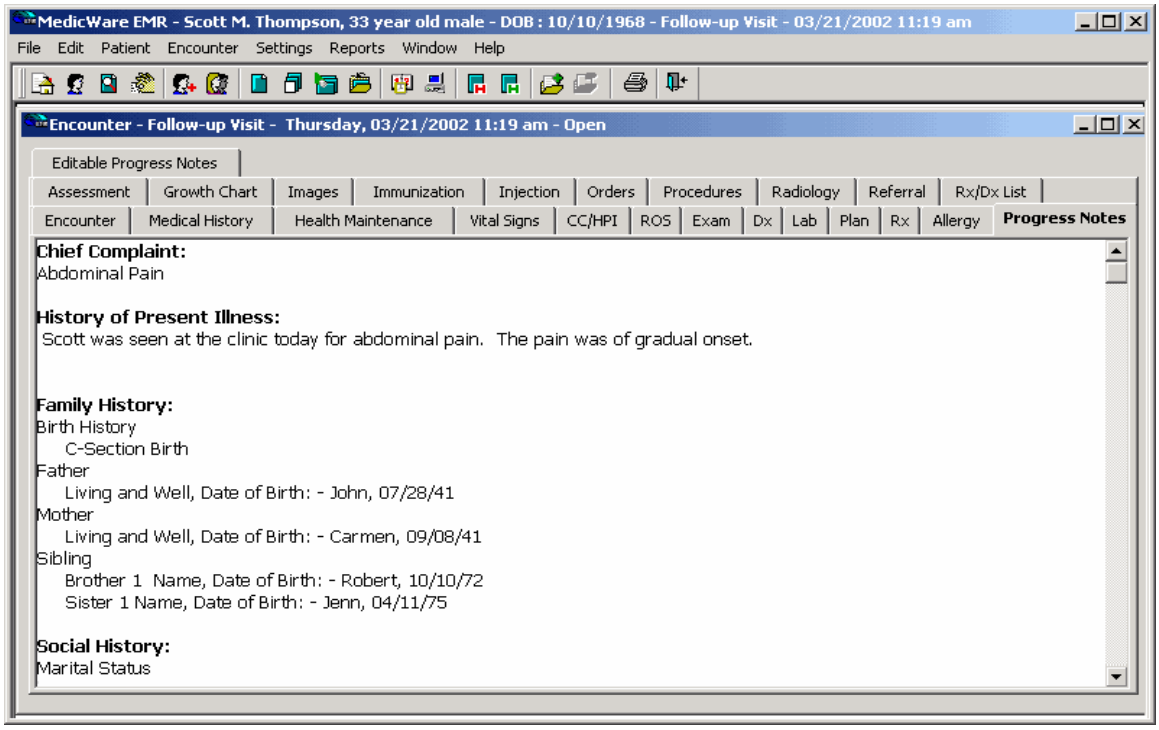

Figure 6 MedicWare progress notes

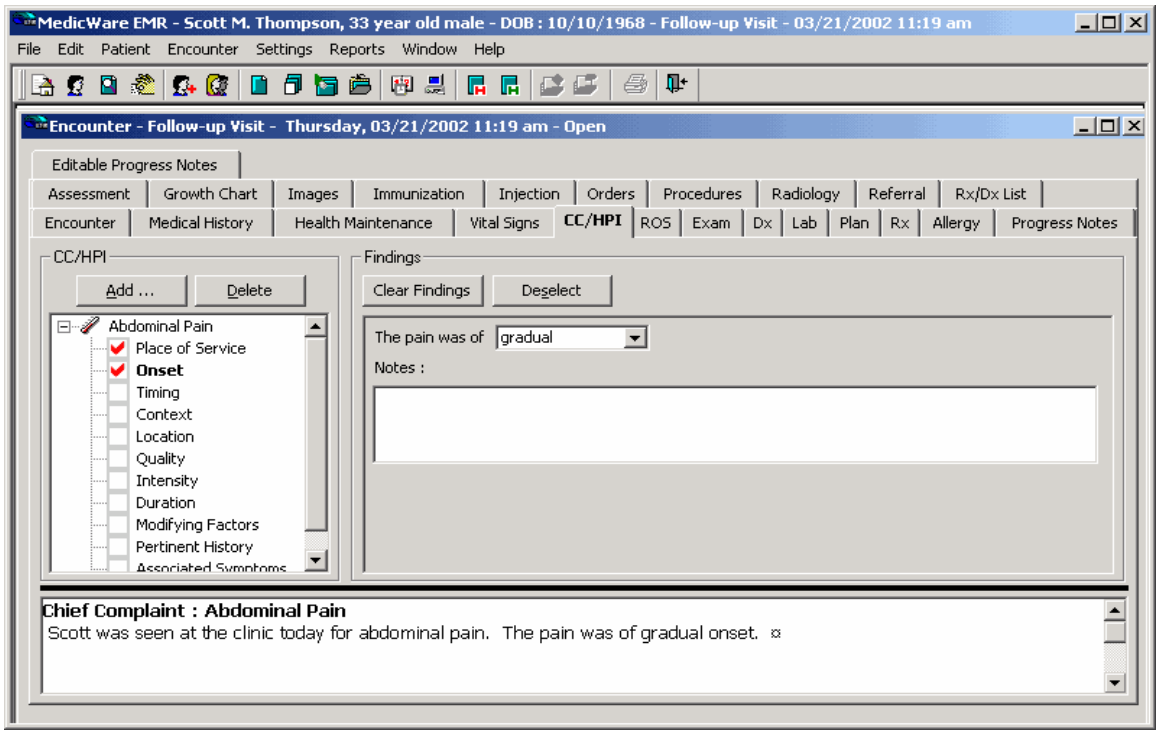

Figure 7 MedicWare templating screen – CC/HPI tab

3.4.4. Problem Summary List

	CareWeb	OTIS	VistA	MedicWare
Usefulness				
Aesthetics				

CareWeb's Problem Summary List (PSL) has been designed to meet UMHS and Joint Commission on Accreditation of Healthcare Organizations (JCAHO) requirements for any patient with more than three visits in the system. In practice, however, the PSL fails to meet the task. Some clinicians ignore the feature altogether, while others enter information with various levels of detail in the diagnosis, procedure, medication, allergy, and health maintenance information text fields. Immunizations, a feature that doctors rarely access, can be found at the same level as the PSL, which is a much more general function. Aesthetically, the PSL's blue headings separate out any of the five categories that have information under them, but the symmetrical look does not distinguish the importance of the information.

Figure 8 CareWeb Problem Summary List

OTIS separates out important information in a "Viewer" feature. The Viewer is essentially a large, scrollable chart of encounters, medication prescriptions, procedures, diagnoses, and even lab results. Rather than forcing clinicians to switch back and forth between encounters, the feature supports scrolling. Details on medications and allergies can be found in the menu at the same level as the Viewer. Unlike CareWeb's free-text solution, medications in OTIS are coded using Cerner's Multum scheme to avoid misspellings and to ascertain which drug is being referred to. UMHS has coded allergens for CareWeb and OTIS in a systematic way as well, though these terms were decided upon by the in house developers.

VistA's CPRS has a "Cover Sheet" feature (figure 9) contains summary lists of Active Problems, Active Medications, Allergies/Adverse Reactions, Clinical Reminders, Recent Lab Results, Vitals, and Appointments/Visits/Admissions. These summaries are adhering to a standard coding system (ICD9-CM) for diagnoses, which reduces the impact of the personal preferences on the amount and type of content in each summary as compared to CareWeb. These summaries, thus avoid redundancies and are also organized in sub-windows rather than one long list. The user can click through to see details on any of these sections. Clinicians report that it serves as a useful starting point.

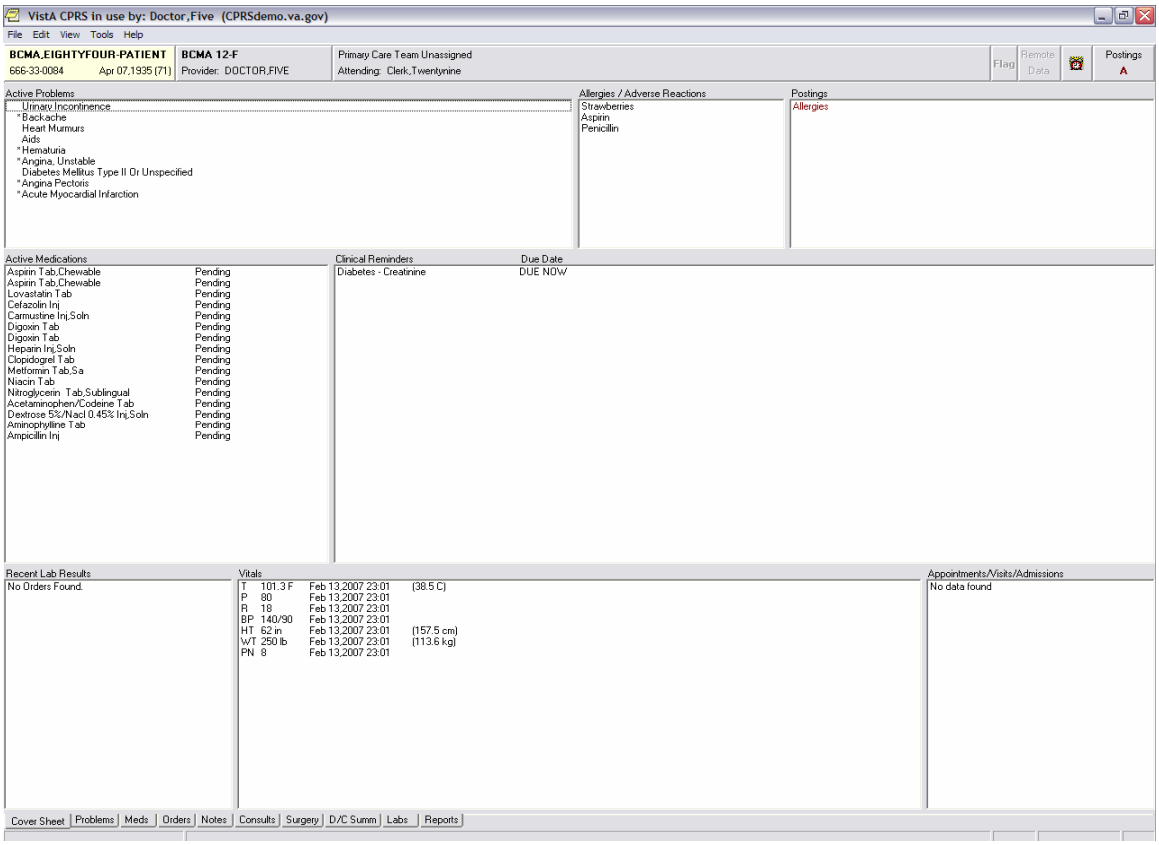

Figure 9 VistA Cover Sheet

Rather than one problem summary, MedicWare users must navigate through many tabbed screens to find the information that VistA's CPRS shows in one screen. Especially pertinent information such as medications and diagnostics are buried within the medical history; procedures, allergies, immunizations, and health maintenance can be found under their own tabs. The tabs themselves can be overwhelming unless a user is very familiar with what features are available in Encounter tabs vs. Patient Information tabs. Having three rows of tabs does not appear to be very appealing aesthetically.

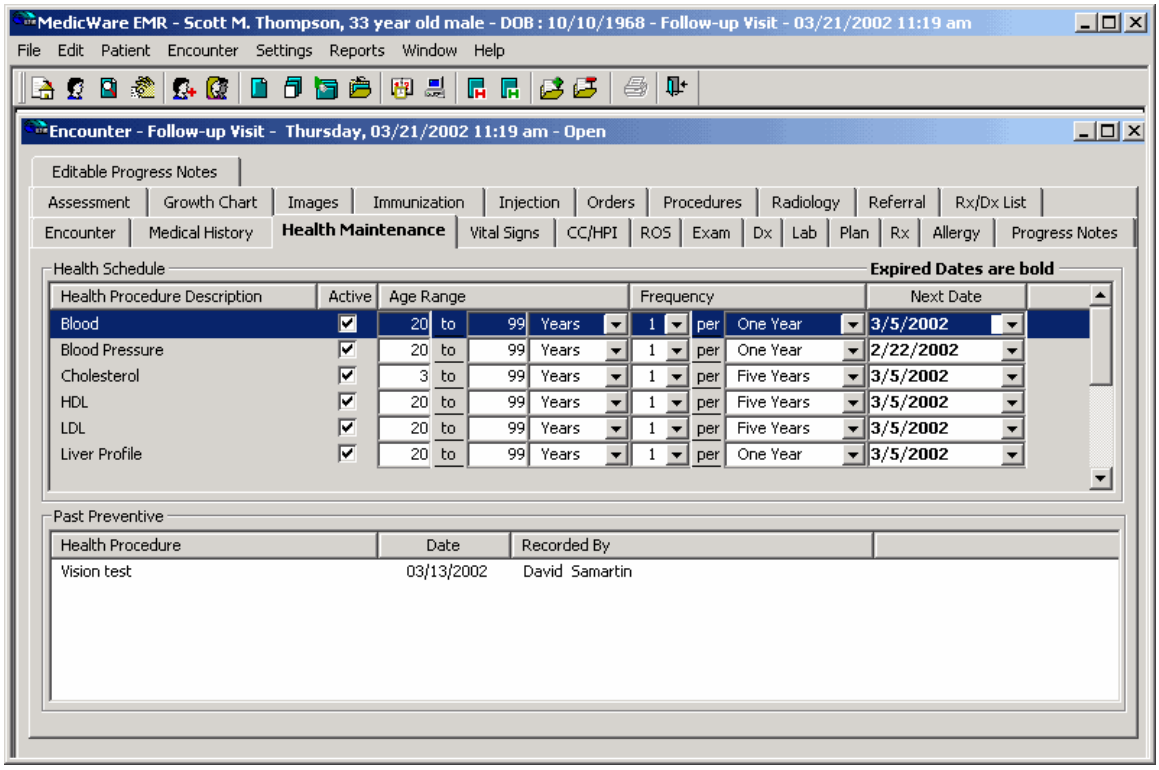

Figure 10 MedicWare Problem Summary

3.4.5. Imaging Test Results

	CareWeb	OTIS	VistA	MedicWare
Usefulness				
Aesthetics				

CareWeb, OTIS, and VistA all utilize STENTOR, a Picture Archive Communications System (PACS) that transmits digital images from medical devices to IT systems. MedicWare. Entering STENTOR from CPRS requires an additional login, detracting from its usability. Aesthetically, however, the graphic images in STENTOR are very faithful representations of the actual film, proving to be a pleasing interface to clinicians interviewed.

The STENTOR demo revealed that some of its innovative features, such as annotation of radiology test results, do not get used by doctors who are not aware that the feature exists or how to use it. The radiology image we observed could be panned in multiple directions and followed the radiologist's mental conception of a film viewer. Text results were available alongside image results. OTIS supported a section where only the text radiology tests results were displayed, which is especially useful for quickly evaluating a transplant patient when a donor is available.

MedicWare, meanwhile, supports uploading of test result images, an extra step that may not be easily completed in the busy physician's office. Its target audience of private practices may find it challenging to purchase more powerful software such as STENTOR when MedicWare is their solution. Without real life MedicWare users, we found it difficult to evaluate.

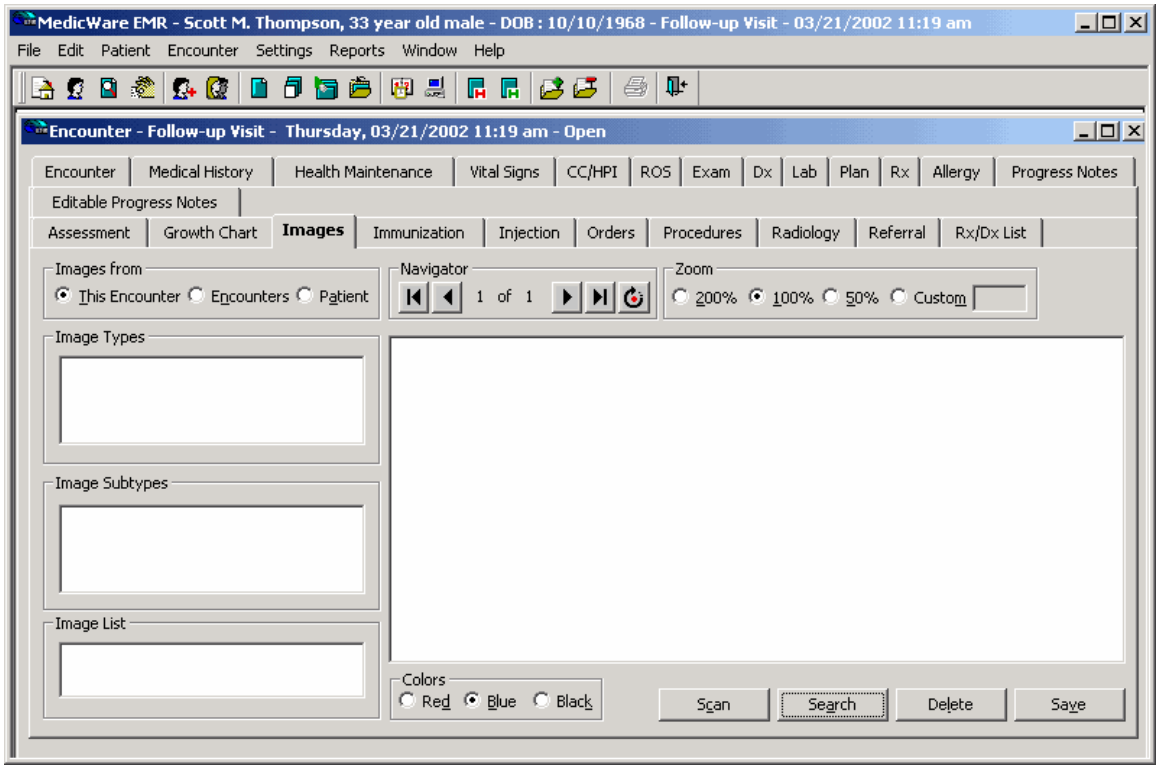

Figure 11 MedicWare Images Screen

3.4.6. Scanned Documents

	CareWeb	OTIS	VistA	MedicWare
Usefulness				
Aesthetics				

CareWeb has a Documents section with a tabbed interface; one of these tabs is "Imaged Documents." The imaged documents tab contains a list of scanned-in documents' dates, document types, and sub-types, with the ability to click through to view each document. The interface is simple, though in practice, not all relevant documents are available for every patient; sometimes outside records just have not been scanned in. OTIS users in the kidney transplant clinic report that these records are particularly crucial for their patients, so they do scan the outside records that they receive or at the very least add outside test result descriptions to OTIS documents.

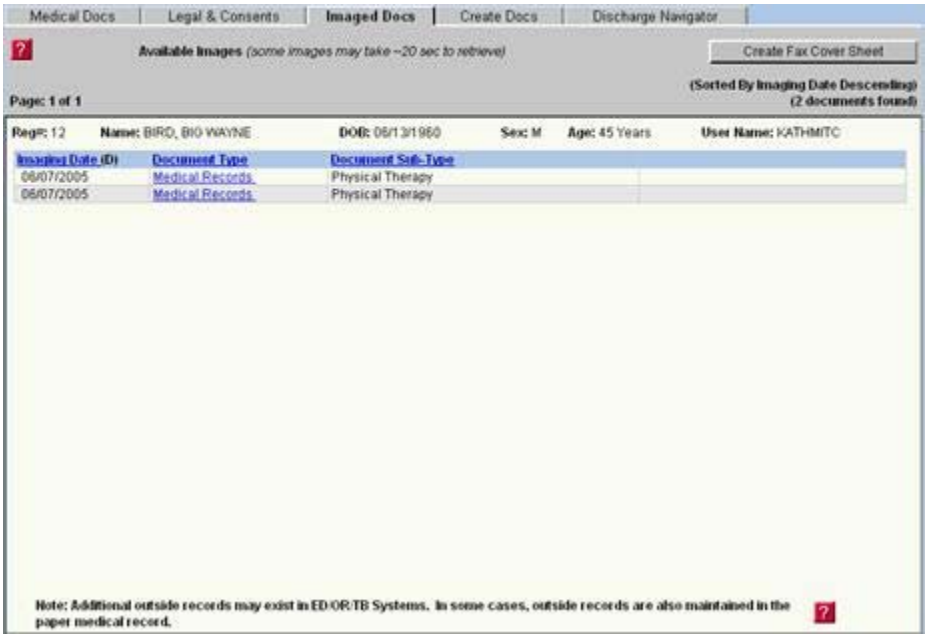

Figure 12 CareWeb Documents/Images Screen

While VistA's CPRS has a scanned document feature, we do not have further information about its usefulness and aesthetics.

In MedicWare, scanned documents are supported in the same fashion as imaged test results; document types and sub-types are created to distinguish the various scanned documents. While radiology film and outside patient records can be accessed from the same page, other even more related features require switching between pages.

3.4.7. Lab Results

	CareWeb	OTIS	VistA	MedicWare
Usefulness				
Aesthetics				

CareWeb and OTIS both draw lab result data from the CDR; the interface to order and report the results of lab tests does not lie within these systems. Both supports selecting lab results by date range as well and lab section. Setting preferences of which levels to view is easier to do in OTIS than in CareWeb. One CareWeb user reported changing his lab result viewing preferences once in MyCareWeb, and that was the only time he ever went to the preferences pages.

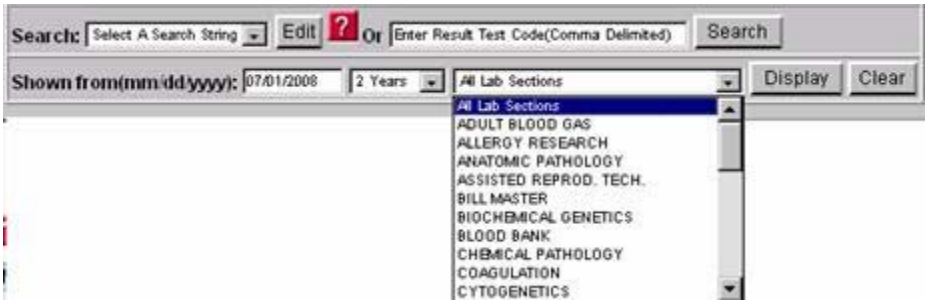

Figure 13 CareWeb lab search screen

The resulting report in CareWeb resembles the figure below. The horizontal axis is the chemical level measured, while the vertical axis is the date of test. These axes can be switched in CareWeb, but in OTIS they are fixed because one particular configuration makes more sense for transplant clinicians in particular. In CareWeb, abnormal lab results are marked with a plain text "H" for high or "L" for low. Meanwhile, since most transplant patients have many health complications, the lab results are not cluttered with additional flags for abnormal results. The lab results report in OTIS is laid out more cleanly than in CareWeb.

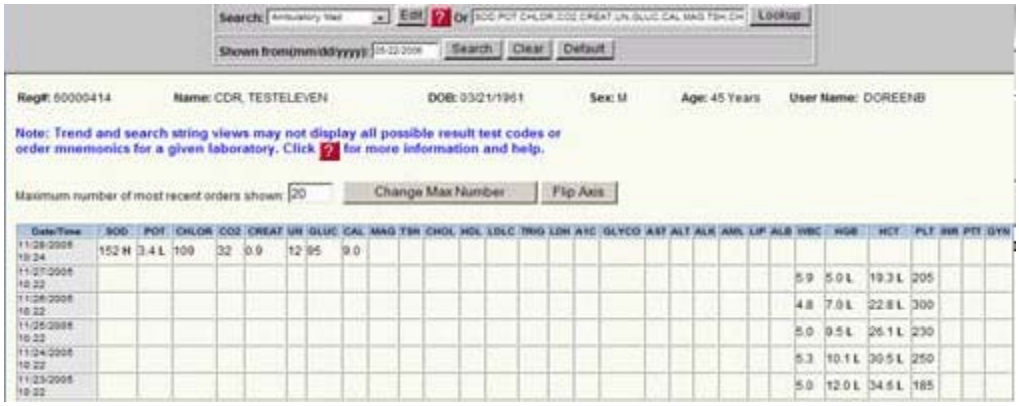

Figure 14 CareWeb lab trend screen

VistA's CPRS has many features for lab results. Hundreds of test types are available to choose from, and unlike CareWeb and OTIS, CPRS supports graphing selected test result values over time. A user can zoom or view a graph in 3D as well. This powerful functionality enables the clinician to spot trends and identify unhealthy spikes.

Like VistA, MedicWare supports lab result graphing. However, the clinicians at the VA appreciated the high level of specificity for the lab result types, whereas MedicWare's interface supports a more simplistic model. In MedicWare, the lab can be ordered in the Encounter section's Lab tab. This is also where the results can be viewed. To add a lab result, the user must manually enter the level being measured and the associated dates. However, MedicWare does support lab result graphing to identify trends over time.

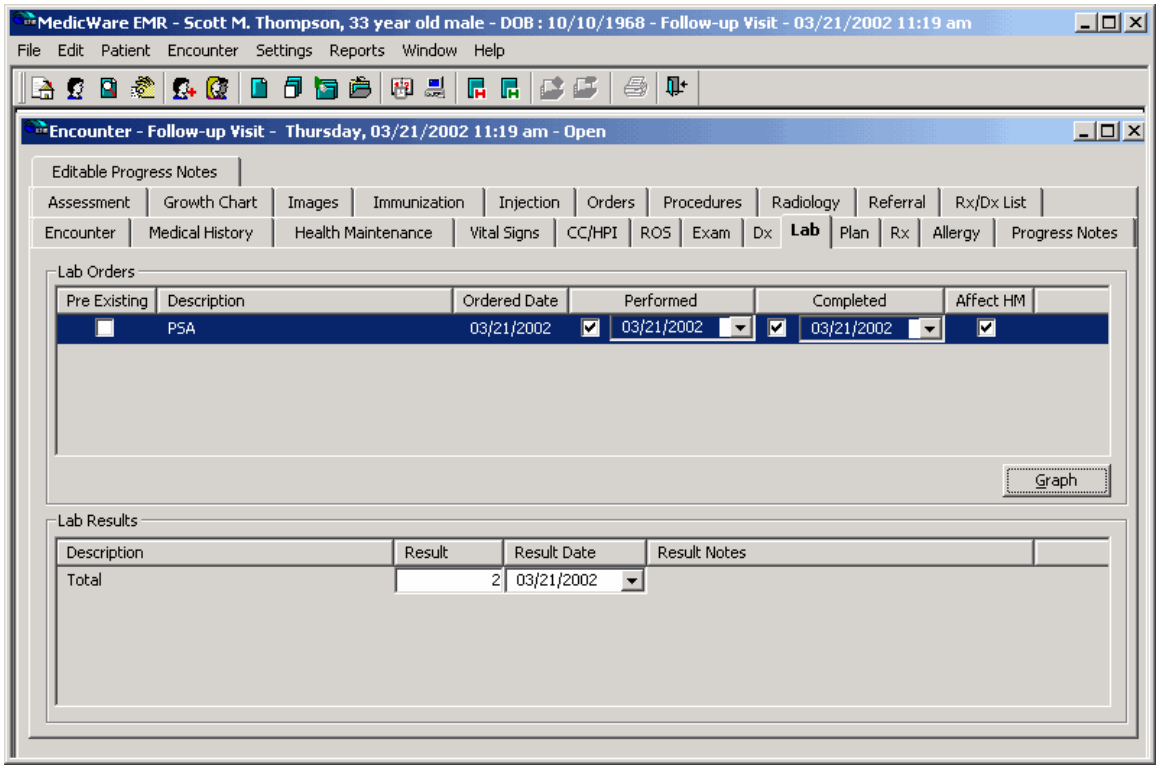

Figure 15 MedicWare visit notes

3.4.8. Vital Signs

	CareWeb	OTIS	VistA	MedicWare
Usefulness				
Aesthetics				

CareWeb recently added a new module called “Continuity” to monitor vital signs and growth data. The vital signs that can be monitored here include weight, height, blood pressure, temperature, and pulse. All the numeric data can be charted, as in Figure X, and growth data can be graphed. Unlike older CareWeb modules, Continuity seems to be better organized for use because the chronological chart layout is not cluttered with too much unrelated data. However, inpatient vital signs are available in Centricity, a inpatient system, or on paper. This kind of information could add to the data an outpatient clinician must wade through.

OTIS users keep track of vitals as well. The “Viewer” feature allows the user to chronologically compare vital signs to other parts of the patient record, such as medications. Medications or procedures that affect a patient’s vital signs could be easily monitored for any unhealthy signs.

Figure 16 Vitals display in OTIS

VistA's CPRS vital signs support pulse, blood pressure, height, weight, and pain in a variety of common date ranges. The results can be graphed to show changes over time and correlations to other vital signs. The summary of the latest vital signs is displayed on the patient record's Cover Sheet.

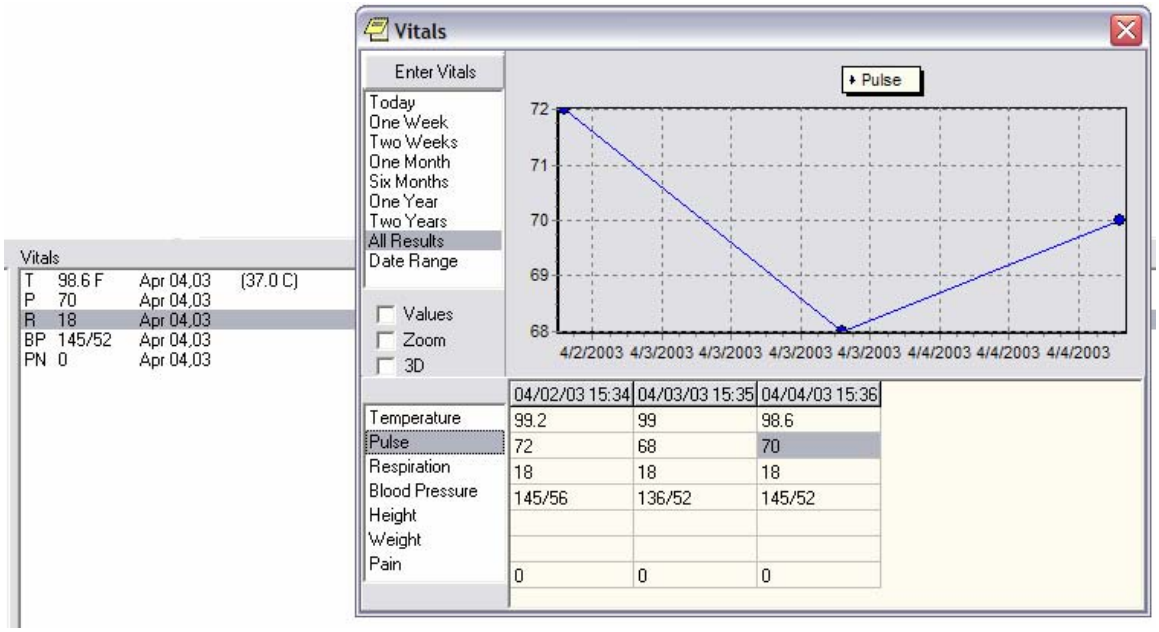

Figure 17 VistA's CPRS vitals display.

MedicWare supports customized vital signs, with user-defined minimum and maximum values. Current vital signs can be entered and the last few encounters' values can be viewed at a time. Though the vital signs lists are scrollable to view older vitals, only the graph feature can support long-term comparison.

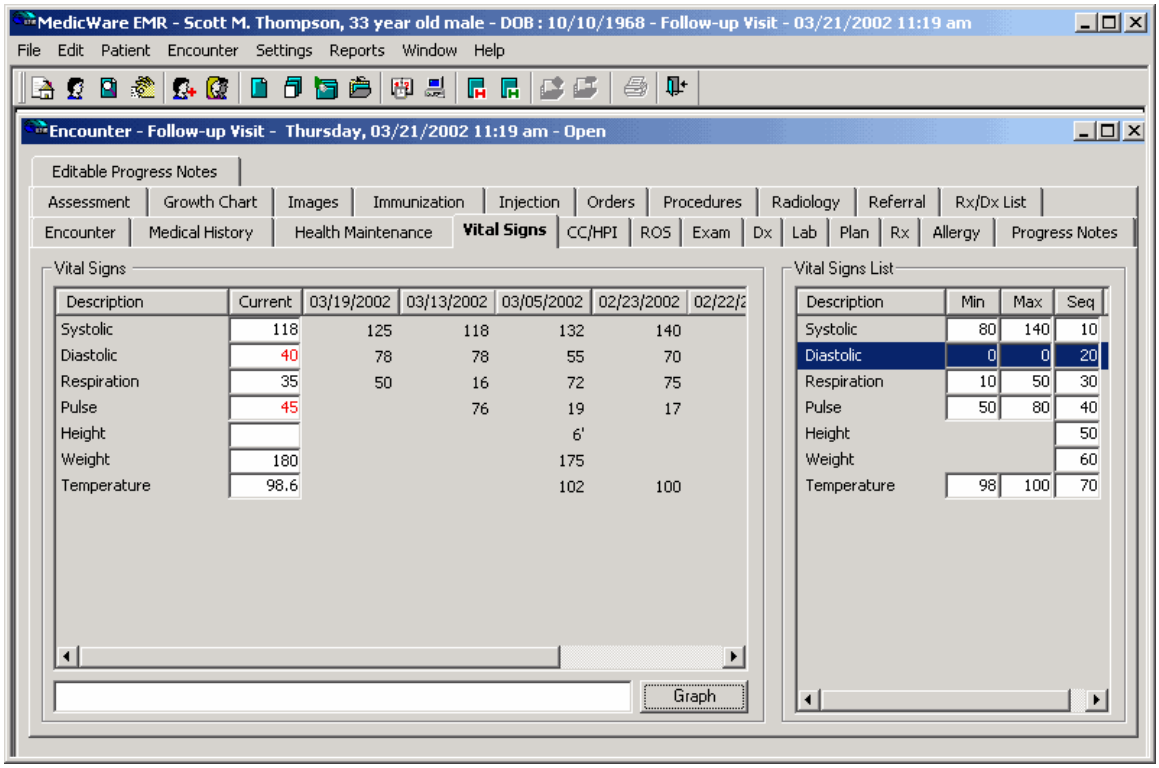

Figure 18 **MedicWare vital tracking**

4. Summary of Findings

All systems we studied provided basic patient record features, such as document and lab results viewing; however, the quality of the solution for each system varied. We have presented comparisons between the demographics, record flagging, document template, problem summary list, imaging test results, scanned documents, lab results, and vital signs features of the four EMR systems.

In terms of demographics, our findings indicate that both OTIS and MedicWare are more useful and aesthetically pleasing than CareWeb. Although both CareWeb and OTIS draw basic demographic information from the CDR, OTIS contains additional contact information, and therefore seems to be more "accurate" and preferred by some of its users. The demographics information is also more clearly organized in OTIS. Some strengths of the MedicWare system are its "Import" and "Capture" image features, which serves to humanize the patient record and allows providers to put a face to a name.

Only OTIS and VistA support record flagging; CareWeb lacks this feature which allows flagging of free-text notes to indicate a particularly noteworthy event. This feature is especially useful in OTIS since the system also supports adding a clinician task to a temporary "Issue List," enabling any transplant clinician qualified to address the issue for the patient to sign on and do so.

CareWeb does not support templates for document creation. Users enter document content into one large free-text field that cannot be marked up. Our interviews with actual users indicate that this is a cause for concern and at times extra work on the part of the users, who may create templates of their own outside the system. In terms of document templates, both OTIS and VistA seem to be useful, while the feature is also aesthetically more pleasing in OTIS. OTIS allows transplant-specific notes in addition to the free-text notes drawn from the CareWeb system. VistA's CPRS offers powerful template document functionality, where pre-existing and shared templates are available, and where users can create their own templates with "Patient Data Objects."

Although CareWeb supports the "Problem Summary List" feature, our interviews with users indicate that while some clinicians ignore the feature altogether, others enter information with various levels of detail. This feature therefore seems not very useful in supporting the medical practice. The aesthetics also do not allow easy distinction between important information. In terms of problem summaries, the OTIS and VistA features seem to be more useful. OTIS allows separation of important information through the "Viewer," which is a large, scrollable chart of encounters, medication prescriptions, procedures, diagnoses, and lab results. Medications are also coded using Cerner's Multum scheme to avoid misspellings and to ascertain which drug is being referred to. VistA's CPRS has a "Cover Sheet" feature that contains various summary lists, such as lists of active problems, active medications, allergies/adverse reactions etc. Problem summaries in MedicWare were not found to be useful since users must navigate through many tabbed screens to find the information that VistA's CPRS, for example, shows in one screen. Pertinent information such as medications and diagnostics are also buried within other sections.

CareWeb, OTIS, and VistA all utilize STENTOR, a Picture Archive Communications System that transmits digital images from medical devices to IT systems. Aesthetically, the graphic images in STENTOR are good representations of the actual film, and seem to be a pleasing interface to the clinicians we have interviewed. In imaging test results, OTIS also supports a section where radiology test results are displayed only in text, which makes it especially useful for quickly evaluating a transplant patient when a donor is available. Imaging test results is not very useful in MedicWare, which supports uploading of images –an extra step that may not be easily completed in the busy physician's office.

CareWeb supports the scanned documents feature, where information on document dates, document types and sub-types may be found. The interface is simple, though in practice not all relevant documents are available for every patient; sometimes outside records are not scanned in. This feature is more useful in OTIS. Users of OTIS in the kidney transplant clinic report that outside records are scanned or at the very least test result descriptions are added to OTIS documents. The scanned documents feature is not very useful in MedicWare as these documents are supported in the same fashion as imaged test results. Pertinent information also require switching between pages.

Our findings indicate that the lab results feature is more useful in VistA as compared to its counterparts in the other three systems. VistA's CPRS has many features for lab results; hundreds of test types are available to choose from. Users are also able to zoom or view a graph in 3D. This powerful functionality enables the clinician to spot trends and identify unhealthy spikes. CareWeb and OTIS both draw lab result data from the CDR, and both support selecting lab results by date range and lab section. On the other hand, lab results are laid out more cleanly in OTIS than in CareWeb.

The vital signs feature is supported by all four EMR systems, although this feature was found to be more useful in OTIS and VistA as compared to CareWeb and MedicWare. CareWeb recently added a new module called "Continuity" to monitor vital signs such as blood pressure, temperature and pulse. All the numeric data can be charted. However, inpatient vital signs are available in Centricity –an inpatient system which can be accessed through CareWeb- or on paper. This kind of information could add to the data an outpatient clinician must wade through. In OTIS, the "Viewer" feature allows the user to chronologically compare vital signs to other parts of the patient record; medications or procedures that affect a patient's vital signs could be easily monitored for any unhealthy signs. In VistA's CPRS, vital sign results can be graphed to show changes over time and correlations to other vital signs. The summary of the latest vital signs is displayed on the patient record's Cover Sheet. In MedicWare, which supports customized vital signs, only the graph feature can support long-term comparison.

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