Accelerating the Benefits of the Problem Oriented Medical Record

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Background

In 1968, Weed wrote the seminal article on the Problem Oriented Medical Record (POMR), *Medical Records that Guide and Teach* [1]. He promoted two major concepts: the Problem Oriented Medical Record framework and a particular *note* structure. Weed wrote that a system with records organized by problems should replace systems organized by source and systems which lacked an organizing framework (both common practices in 1968). He suggested that progress notes should adhere to a structure with five elements: Subjective, Objective, Rx, Interpretation and Plan [1, 2]. This five-component structure evolved to the four-component Subjective, Objective, Assessment and Plan structure, now commonly known as SOAP. Although the SOAP note structure has been widely embraced, adoption of the POMR has been more limited.

Given the numerous potential benefits, Simons et al. recently surveyed the literature and published the attributes (called *determinants*) necessary for success of the POMR [3]. The authors list twelve determinants, including functionality, completeness, and efficiency. One aspect of functionality is specified as "context dependent views of all data". A framework using these context (problem) dependent views is the *Problem Oriented View* (POV). The use of POV to accelerate POMR adoption is the focus of this editorial.

This editorial will highlight some crucial studies and commentary on the POMR, outline a POV model and discuss the use of problem concept maps (PCMs) as an enabling methodology to generate the POV within an EHR. The POV will save busy clinicians time and work, as the computer will be able to organize and display data by problem, while continuing to offer current display frameworks.

The Meaningful Use Stage 1 Core Measure specification defines the problem list as *a list of current and active diagnoses as well as past diagnoses relevant to the current care of the patient* [4]. Clinician attitudes about using the problem list vary widely [5]. Problem lists are subject to the network effect, in which goods or services becomes more valuable when more people use them [6]. Because problem lists have not been fully adopted, those of us who do use the framework do not experience the maximum potential benefit. Investigators have addressed the challenge of incomplete adoption by working on tools to improve completeness [7, 8, 9] and by suggesting approaches for lowering the complexity of problem list maintenance [10, 11].

The advent of the EHR seemed to offer a path toward implementation of the POMR. Even in 1968, one of the many striking aspects of Weed's article was his vision for using the computer to leverage his concepts. However, the progress on this path has been laborious and slow. Strict adherence to Weed's recommendations involves creating formatted problem-oriented progress notes. The use of such notes likely helps to improve clinical thinking, especially among trainees [12, 13]. In theory, charting by creating problem-oriented progress notes on a computer allows others to view an organized document sorted by problem. However, many EHR users do not generate problem-oriented notes because the creation tools are so inefficient. The POV model will allow EHR users to see data and documentation organized into a problem-oriented view, *even if prior notes were not created using computerized problem-oriented charting.*

For many years, EHRs have been organized primarily by data source (clinic notes, hospitalizations, lab results, imaging reports, diagnostic procedure, etc.) and secondarily by chronologic or reverse chronologic order within that data source. Separate storage and indexing of inpatient and outpatient information tend to fragment individual patient records. The EHR offers the tantalizing possibility of adding a POMR view to the established source/chronologic-oriented medical record. However, the realization of a computerized problem-oriented view has been quite challenging for vendors and users.

Paper records lent themselves to a chronologic or reverse chronologic structure. Hospitalizations were marked with tabs that showed the admission and discharge dates (▶Figure 1). Lab and x-ray reports were placed in the chart using the *shingle method* (▶Figure 2).

As they created computer interfaces for data retrieval, many EHR vendors "paved the cowpath" [14] when they computerized the chronologically oriented scheme of the paper record. Within each domain (notes, lab data, medications, imaging, and diagnostic test results), vendors created an electronic chronologic index. This type of orientation can be useful, especially when the user needs to focus on the most recent data in a domain. However, a display with aggregated data [15] is essential

to realize Dr. Weed's vision of the problem-oriented record. Vendors should give users both options, providing an EHR that allows a viewer to toggle back and forth easily between a chronologic and a problem-based display.

Without computerized data aggregation, EHR users who wish to view data by problem must organize the data themselves. They must establish links from the problems to relevant data and notes, and/or copy and paste lab, imaging, and procedure data and consultant notes into the annotation section of the problem list. This is a time-consuming task for users, and one that is not practiced consistently.

Model Approach

A user-friendly problem based record should offer on-demand display of aggregated data and notes relevant to a particular problem. These data or links to these data will only display when the user selects the problem. When that problem is not being reviewed, the data display will collapse and take up no screen space.

By combining the problem list with problem concept maps (PCMs), our model generates a dynamic display of the POMR. PCMs are similar to problem concept-oriented views, which are well described by other investigators [16,17]. We propose using the problem list and PCMs to automatically create a POV. The user initially sees the problem list (▶Figure 3). When the user clicks on the problem of interest, the system creates the POV for that problem (▶Figure 4). This view is dynamically created *at the time of display, rather than trying to store the data in a problem-based structure.*

Model Implementation Methodology

For common problems, hard coded PCMs will be stored at the system level. The concept maps will be built with standard public domain vocabularies such as SNOMED for problems, RxNorm for medications, LOINC for laboratory results and radiology results, and ICD-10 codes for encounters/hospitalizations. The vocabulary for diagnostic procedures remains to be determined. The EHR will use these PCMs to display medications, results (lab, imaging, and diagnostic procedures), and relevant documentation in a problem-oriented manner. The first component of a map is a cluster of SNOMED codes, which represent the problems that will trigger the system to use the map. Then relevant medications and lab tests will be added to the map, using RxNorm codes and LOINC codes, respectively. Additional codes for imaging and diagnostic procedures will be added. Finally visit diagnosis codes are added. The medication and lab section of a diabetes problem concept map is shown in ▶Figure 5.

The individual *map component links* that constitute Problem Concept Maps will be used, along with *indication links* and *manual links,* to create the dynamic displays needed for the problem-oriented view. These three link types are defined in ▶Table 1. Although providers often do not currently document the indication for a prescribed medication, this should change as providers see the numerous advantages of recording the indication [18].

▶Table 2 shows the functionality, maps and links needed for each data type to generate a robust dynamic POV. PCMs containing component links are the building blocks of our model, enabling the computer to create a dynamic display of aggregate data.

In this model, the system can use concept maps to create a dynamic display based on *relationships drawn from the maps at the time the display is created*. If no PCM is available, the system can use any existing manual links or indication links to create a dynamic display based on *relationships previously created* for that patient's record. Though the use of indication links is likely to grow (see above), the burden of creating manual links will be relieved as PCMs and automatic dynamic displays become more widespread.

Various vendors provide some of the items listed in ▶Table 2. At the University of Wisconsin, Epic provides the functionality for items 1, 2, 3, 4 and 5, and UW has implemented concept maps for medications and labs, for seven problems.

Model POV Example

Suppose that the provider views the problem list (▶Figure 3), focuses on a particular problem and selects it. Using the SNOMED code for that problem, the system retrieves the associated PCM. The system then uses the RxNorm, LOINC, and other codes in that PCM to find relevant data in the individual patient record containing these codes. The data retrieved are shown on the screen, and aggregated under that particular problem (▶Figure 4). A problem concept map will also contain the provider specialties, clinic specialties and billing diagnoses related to that particular problem. The system can then use the map with scheduling and billing codes to identify relevant encounters and display links to the documentation from those encounters.

For a given problem, POV software will display links to entire notes related to the associated billing diagnosis or specialty (▶Figure 6). Additional specificity will be gained if the note author has documented the name of the problem just before the assessment and plan paragraphs for that problem. Then the system can use simple natural language processing to link directly to that section of the assessment and plan (▶Figure 7). The use of such a direct link will save time for users.

Additional Considerations

The Problem Oriented View is intended for viewing and to assist with clinical decision making. POV is not intended for note generation. Users may be tempted to use POV to create progress notes that serve as all inclusive summaries. With a few exceptions such as consult notes, this temptation should be avoided, because it will accelerate note bloat. Instead, users should develop confidence that they can use POV to generate a problem-based aggregate display at any time, rather than searching for prior summary notes that are created repeatedly at each encounter.

The title of a given problem can change over time, as when an *initial disease* evolves into a different problem (e.g., *impaired fasting glucose* evolves to *diabetes*), or a *symptom problem* is identified to be a *disease process* (e.g., *shortness of breath* is found to be caused by *chronic pulmonary emboli*). For problem-data relationships based on problem concept maps, these title changes will cause no difficulty, because the system will dynamically generate the data display when the user clicks on the linked new problem name. For problem-data relationships based on an indication links or other type of links, the physician may need to generate links to the new problem title. Then an accurate problem-oriented view will be accessible.

We have created five problem concept maps using expert consensus across six academic medical centers. This process combines a modified Delphi technique with consensus decision making. The experts first vote and make suggestions anonymously. Then they interact asynchronously using Google Drive to advance toward consensus. In the last step, the consensus is finalized in a one hour conference call. The time needed from each volunteer subject matter expert is 2 to 4 hours. Paid staff perform central coordination of the process. We will be posting maps at problemlist.org.

Success of the Problem Oriented View model will require significant curation and knowledge management resources for construction and maintenance of the Problem Concept Maps. Just as LOINC and SNOMED undergo periodic review [19,20], each of the problem concept maps will need yearly review. As the RxNorm, LOINC, and SNOMED vocabularies require paid professional staff to provide long term support, the problem concept maps will require paid staff to facilitate the work of the volunteer subject matter experts.

Summary

The Problem Oriented View model we have described will generate an on-demand dynamic display of aggregated data and documentation (or index hyperlinks to those data and documentation) in the problem list. The existence of a Problem Concept Map along with a problem list entry for the problem of interest will allow the user to easily view aggregate data and documentation for that problem. The original data and documentation will continue to be stored in the usual manner. Exist-

ing reverse chronologic views of data will still be available. Implementation of this model will bring us significantly closer to Weed's vision of the Problem Oriented Medical Record.

Multiple Choice Questions

1. What is the network effect?

A The phenomenon by which the availability of multiple wireless access points in a building allows better access to the Internet
B The problem in which too many people using the same wireless access point causes overcrowding and decreased Internet speed
C The phenomenon by which goods or services become more valuable when more people use them
D The problem in which too many wireless access points in the same building cause interference and corruption of Internet traffic

The correct answer is (C). The *network effect* is the effect that one user of goods or services has on the value of those products to other people. When a network effect is present, the value of a product or service is dependent on the number of others using it. [6,21] Classic examples of the network effect include the telephone and the Internet.

If too many people are using the same wireless access point or too many wireless access points in a building cause interference, then there is said to be *network congestion*. The availability of multiple wireless access points may indeed allow better access to the Internet, but this occurs via relief of network congestion and is *not* called the network effect.

2. The Meaningful Use Stage 1 Core Measure specification defines the problem list as:

A A list of all past illnesses, all past surgeries, and ongoing medical conditions
B A list of current and active diagnoses as well as past diagnoses relevant to the current care of the patient
C A list first described by Dr. William Osler in 1868, and which facilitates the creation of a Problem Oriented Medical Record
D A list of medical conditions that require ongoing treatment and monitoring, for example diabetes

The correct answer is (B). The Meaningful Use Stage 1 Core Measure specification defines the problem list as a list of current and active diagnoses as well as past diagnoses relevant to the current care of the patient. [4]

The specification makes no explicit mention of including past surgeries, although providers may choose to include previous surgeries relevant to current care. There is no requirement to include all past illnesses. The Problem Oriented Record and problem list were described in 1968 by Dr. Lawrence Weed.

Conflicts of Interest
The author has no conflicts of interest to report.

Human Subjects Research Statement
This manuscript did not involve research on human subjects

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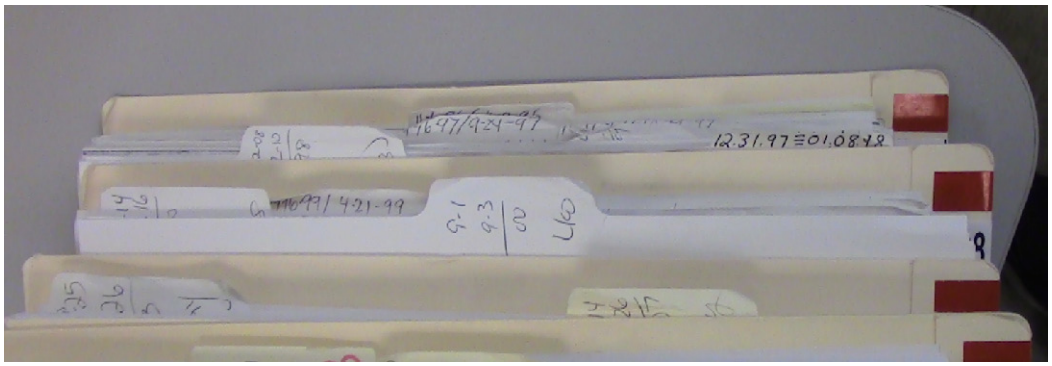

Fig. 1 Record of Hospital Admissions in Chronological Order

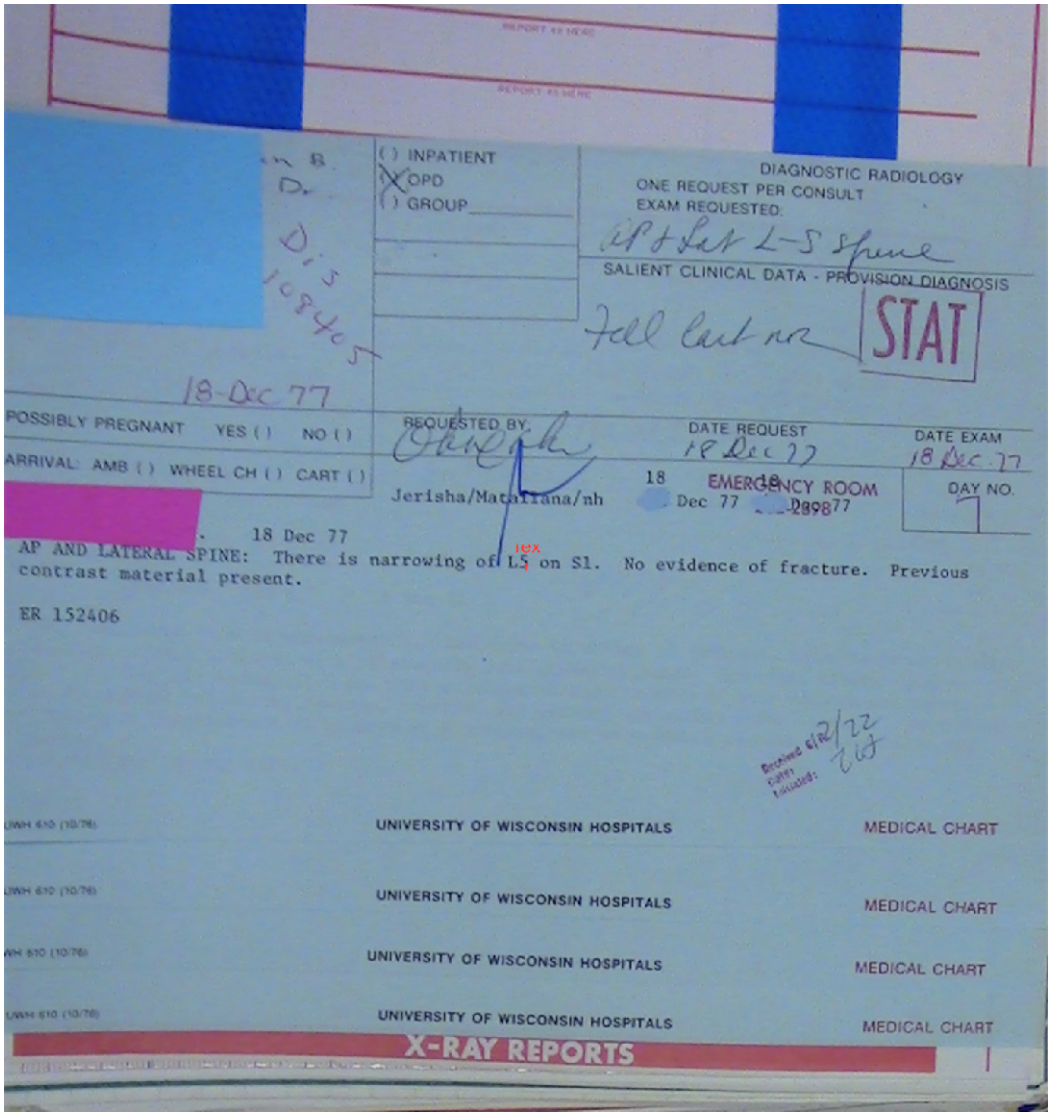

Fig. 2 X-Ray Reports Stored with the Shingle Method

Problem List

Endocrine

- Diabetes

Musculoskeletal

- Degenerative Joint Disease

Neurologic

- Epilepsy

Fig. 3 Problem List without Showing any Aggregated Data

Problem List

Endocrine

- Diabetes

Musculoskeletal

- Degenerative Joint Disease

Neurologic

- Epilepsy

Meds

lamOTRIGINE (LAMICTAL) 100MG tab	Take 2 tabs (200mg) in the AM & 1.5 tabs (150mg) in the PM. (Take crushed per G-Tube)	105 tab	6 ordered	6/10/2015
midazolam (VERSED) 2MG/ML syrup	Give 7ml per g-tube for seizures greater 5 minutes. Limit once daily.	100 ml	3 ordered	7/2/2015

Labs

LAMOTRIGINE	4.8	1/11/2014

Imaging

9/12/2012	MRI HEAD W & W/O CONTRAST

Impression: 1. Findings compatible with bilateral Sturge-Weber syndrome with associated

Procedures

12/14/2012	Routine EEG

CLINICAL INTERPRETATION: This EEG recording is abnormal due to generalized slowing and disorganization.

Clinic Notes

3/11/2015	Epilepsy	Dr. Stanley
9/23/2014	Neurosurgery	Dr. Livingstone

Hospitalizations

7/31/2014	Neurosurgery	Dr. Livingstone
8/2/2013	Neurology	Dr. Stanley

Fig. 4 Aggregated Data for the Problem of Epilepsy, Showing Lab and Medication Data and Links Which Give Access to Full Data for Imaging, Procedures and Notes

Diabetes *Problem Concept Map*: Lab Tests and Medications (Partial Listing)

Lab Test	LOINC Code
GLUCOSE	2345-7
GLUCOSE, FASTING	1558-6
HEMOGLOBIN A1C	4548-4
MICROALBUMIN/CREATININE RATIO	3000-4
CREATININE	2160-0
E-GFR	33914-3
POTASSIUM	2823-3
LDL CHOLESTEROL, CALCULATED	13457-7
LDL CHOLESTEROL	2089-1
LDL CHOLESTEROL, DIRECT	18262-6
CHOLESTEROL	2093-3
HDL CHOLESTEROL	2085-9
CHOLESTEROL/HDL RATIO	2095-8
NON-HDL CHOLESTEROL	43396-1
TRIGLYCERIDES	2571-8

Medication	RxNorm Code
Acarbose	16681
Miglitol	30009
Metformin HCl	235743
Alogliptin Benzoate	1368000
Linagliptin	1100699
Saxagliptin HCl	1043560
Sitagliptin Phosphate	621590
Bromocriptine Mesylate	142426
Dulaglutide	1551291
Exenatide	60548
Liraglutide	475968
Insulin Aspart	51428

Fig. 5 Example of a Problem Concept Map

ASSESSMENT/PLAN:

Hypertension

Overall he has done pretty well in these last months. His weight has dropped substantially with diuresis from about 400 pounds last May to 365# last June and 362# at the end of September 2014. His weight in clinic today was 369#. Most notably, his echocardiogram has substantially improved. On September 24 his left ventricle appear normal in both size and function. There was mild concentric hypertrophy. His left atrium is quite dilated. Overall, this is a substantial improvement and reassuring that the hypertension may have been the primary cause of his LV dysfunction.

As of today, his regimen includes lisinopril 10 mg a day replacing the hydralazine and his bumetanide is down to 1 mg daily. His carvedilol is the same. His pressure in clinic today was low normal and we chose to reduce his amlodipine dose down to 5 mg daily.

Plan: Reduce amlodipine from 10 to 5 mg. No other changes for now.

Dyslipidemia

He is currently taking atorvastatin 40 mg. His most recent lipid panel has an LDL of 74, HDL 33 triglycerides 228. The biggest remaining issue here is his high triglyceride/low HDL which is being driven by likely a combination of his weight and his genetic background. At this point the bulk of his risk is addressed with the atorvastatin and we may no changes to that dose.

Plan: Focus on diet and exercise shifts to lose weight in the lipid number should follow in line. He met with our dietitian today as well at her notice added separately.

Renal insufficiency

Creatinine numbers were elevated on admission May 2014. He switched from hydralazine to lisinopril last spring and his numbers have remained moderately elevated from 1.74 (GFR 47) to 2.96 (GFR 25). Most recent is 1.73. He has been seen by the renal transplant team, and similar to his echocardiograms, they saw significant proteinuria last spring, but repeat urinary analysis in January showed no protein.

Plan: No specific changes recommended.

Fig. 6 Assessment and Plan Section of a Compete Cardiology Note. A Link to this Note Would be Generated from Each of Three Problems in Problem Oriented View

Dyslipidemia

He is currently taking atorvastatin 40 mg. His most recent lipid panel has an LDL of 74, HDL 33 triglycerides 228. The biggest remaining issue here is his high triglyceride/low HDL which is being driven by likely a combination of his weight and his genetic background. At this point the bulk of his risk is addressed with the atorvastatin and we may no changes to that dose.

Plan: Focus on diet and exercise shifts to lose weight in the lipid number should follow in line. He met with our dietitian today as well at her notice added separately.

Fig. 7 Natural Language Recognition of Problem Based Section Headings will Allow Storage, Retrieval and Display of the Assessment and Plan that are Particular to a Specific Problem

Table 1 Link Types Used for Dynamic Creation of Problem Oriented View

Item #	Link Type	Definition	Time of Creation	Storage Location	Example	Essential for Problem Concept Maps	Value
1.	Map Component Link of a Problem Concept Map	A problem concept map component link is a connection specified in the system, between a cluster of SNOMED problem codes and codes for medications, labs, imaging procedure and diagnostic procedures	Time of System Setup	System Level	COPD and Alpha-1-Anti-Trypsin Level	Yes	Automatic; Does not depend on indication links and manual links which often do not exist
2.	Indication Link	An indication link is a connection between a medication, treatment or other orderable item and a particular visit diagnosis or problem for a patient. The link is created at the time of ordering.	Time of Ordering	Patient Level	Albuterol ordered with a specified indication of COPD	No	Reflects the intent of the prescribing provider
3.	Manual Link	A manual link is a connection between a medication, lab result, imaging result, diagnostic procedure result or segment of narrative text and a particular problem for a patient.	Sometime After Ordering or While Documenting	Patient Level	Link between COPD and a narrative progress note about the COPD	No	Allows creation of a link to data or documentation in the absence of a problem concept map for that type of information

Table 2 Maps, Links and Functionality Needed for Generation of Problem Oriented View

Item #	Type of Data	Map, Link or Function	Details
1.	Ancillary Data	Problem Concept Map (with component links)	System allows storage of *hard concept maps* that specify which ancillary data should be displayed when drilling down on particular problem (e.g. HgbA1C, creatinine, GFR and microalbumin/creatinine ratio for the problem of diabetes)
2.		View	System uses a dynamic display to view ancillary data (e.g. lab data, imaging reports, diagnostic procedure reports) in a problem oriented structure upon drilling down on a particular problem. Items are included in the display based on a *concept map relationship*.
3.	Medications and Other Treatments	Indication Link	Requirement for providers to specify an indication/problem for all medications and other treatments, so they can be displayed when that problem is selected.
4.		Problem Concept Map (with component links)	System allows storage of *hard concept maps* that specify which medications should be displayed for a particular problem (e.g. for diabetes, this would include all insulins, sulfonylureas, biguanides, DPP-IV inhibitors, alpha-glucosidase inhibitors, thiazolidinediones, peptide analogs and glycosuric drugs). These medication maps are necessary because it will be some time before software can be implemented that requires an indication for every medication prescription.
5.		View	System uses a dynamic display to view medications and other treatments related to a given problem, upon drilling down on a particular problem. Items are included in the display based on an *indication link* or a *concept map relationship*.
6.	Documentation	Manual Link to Entire Note or to Assessment/Plan	Ability for documenting providers to use labels, links or templates to tie their documentation to a given problem.
7.		Problem Concept Map (facilitates display of entire note)	When the user clicks a problem hyperlink, the system dynamically generates a linked index of clinic notes, discharge summaries and consult notes related to that problem, utilizing the encounter diagnosis, provider specialty or clinic specialty for the individual piece of documentation.
8.		System Creates Tags for Assessment/Plan Sections	The system has the ability to utilize basic NLP to tag assessment/plan paragraphs with the name of existing patient problems. When the user clicks a problem hyperlink, the system dynamically generates a linked index of these assessment/plan paragraphs.
9.		View	Ability to display a hyperlinked index of provider documentation (clinic notes and hospital admission notes, daily progress notes and discharge summaries and operative notes) in a problem oriented structure. Items populate the index based on *manual links*, *concept map relationships*, or *tagged assessment/plan text*.

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