Language Technology, Electronic Health Records, and the Clinical Narrative

Philip Resnik, Ph.D.
University of Maryland
CodeRyte, Inc.
Electronic health records are a big deal.
“The Electronic Health Record (EHR) is a **longitudinal electronic record** of patient health information generated by one or more encounters in any care delivery setting. Included in this information are patient demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data, and radiology reports. . . .”
In the United States there are on the order of 2,000,000,000 doctor-patient encounters per year; that’s over 200,000 an hour.

On April 26, 2004, President Bush announced the goal of assuring that most Americans have EHRs within the next 10 years, i.e. in 2014.  

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1550638/  

The Health Information Technology for Economic and Clinical Health (HITECH) Act was passed in 2009. It authorizes expenditures of at least $20,000,000,000 to promote the adoption and use of EHR technologies.  

http://itlaw.wikia.com/wiki/HITECH_Act
• Which decision is supported by the best evidence?
• How well does a proposed treatment work?
• Does drug effectiveness vary by patient population?
• Who are the good candidates for a clinical trial?
• Which caregivers are following best practices?
• Are more cost-effective options being overlooked?
• Are we seeing evidence of a new epidemic?
• Are we seeing evidence of a biological attack??
• Are we seeing evidence of an alien invasion???

Ok, maybe not that.
Those applications all require patient data that is suitable for analytics.

The obvious solution is to have healthcare providers enter patient data that is suitable for analytics.
Providers

CHIEF COMPLAINT:
Shortness of breath.
HPI: This is a 68-year-old female who presents to the emergency department with shortness of breath going for several days …

Payers

Coding Tools & Services

12002
873.0

$$
“This system is designed for physicians to point and click their way through an entire exam quickly and effortlessly.” (EMR product review)
1 Tablet(s) PO Daily
Take 1 tablet by mouth daily.

1 tab by mouth or orally daily
Take 1 tablet orally Daily

1 tab orally every 24 hours.
Take 1 tablet orally every day

1 tab(s) PO (oral) qDay
Take one orally daily

1 tab(s) orally once a day.
Take one orally daily as discussed

1 tabs QD
Take one tablet by mouth daily

1.0 tab po qd
Take one tablet by mouth every day

ONE TABLET; ORAL QD
Take one tablet daily

One orally daily
Take one tablet once per day orally

One tablet po daily
Take one tablet po qd

TAKE 1 TABLET DAILY
by mouth one po qd

TAKE ONE PO QD
one orally once a day

Take 1 Tab by mouth daily.
one orally per day

Take 1 tab daily daily orally
one tablet by mouth daily

Take 1 tab daily orally
one tablet daily

Take 1 tab po qday
one tablet once a day

Take 1 tab qd po
take 1 tab po daily

Take 1 tab qday PO
take 1 tab po qd

Take 1 tab(s) daily orally
take one orally each day
But…

The path we are taking to EHRs threatens to disrupt or even do away with the natural use of language in clinical records.

And the language in clinical records is also a big deal.
“...In years past, a well-written history and physical, or progress note, would unfold like a story, giving a vivid description of the patient’s symptoms and physical exam at the point of the encounter, as well as the synthesis of the data and the plan of care."

April 14, 2007

CHIEF COMPLAINT: Shortness of breath.

HISTORY OF PRESENT ILLNESS: This 68-year-old female presents to the emergency department with shortness of breath that has gone on for 4-5 days, progressively getting worse. It comes on with any kind of activity whatsoever. She has had a nonproductive cough. She has not had any chest pain. She has had chills but no fever.

EMERGENCY DEPARTMENT COURSE: The patient was admitted. She has had intermittent episodes of severe dyspnea. Lungs were clear. These would mildly respond to breathing treatments and morphine. Her D-dimer was positive. We cannot scan her chest; therefore, a nuclear V/Q scan has been ordered. However, after consultation with Dr. C, it is felt that she is potentially too unstable to go for this. Given the positive D-dimer and her severe dyspnea, we have waved the risks and benefits of anticoagulation with her heme-positive stools. She states that she has been constipated lately and doing a lot of straining. Given the possibility of a PE, it was felt like anticoagulation was very important at this time period; therefore, she was anticoagulated. The patient will be admitted to the hospital under Dr. C.
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May 3, 2007

EMERGENCY DEPARTMENT COURSE: The patient was admitted and nontoxic in appearance. **Blood pressure was brought down aggressively. With this combined with BiPAP, she has reversed her respiratory distress promptly.** She has improved significantly. She will not require intubation at this time period. Her family has elected to go back to M, Dr. W. I did discuss this case with Dr. G who is on call for L Cardiology. She has accepted him in transfer; however, there are no PCU or ICU beds at this time period. Will admit here for a brief period until a bed is available at M. I discussed this case with Dr. R who will admit.

Clinicians were trying to determine whether the shortness of breath was due exclusively to her failing heart, or whether she has pneumonia.

Prompt response indicates that pneumonia is not the issue.
I worry that EMRs as implemented can actually downgrade the quality of information passed between health care teams

Previous EMR studies neglect the narrative

• Adoption
• Cost
• Economic value
• Quality of care metrics

• *No previous study directly compares clinical communication using free dictations with clinical communication using EMRs.*
Mr. John Roe was seen in our office today in follow up of his paroxysmal atrial fibrillation. As you know, he is a 57 year old gentleman who had electrical cardioversion in May 2002 and had been maintained on Betapace since that time. His last visit in our office was July 23, 2003. He recently called our office in February stating he was back in atrial fibrillation which was documented on electrocardiogram. I elected to increase his Betapace to 160 mg twice a day and he did convert back to normal sinus rhythm. We had recommended Coumadin to him at that time but he did not start any Coumadin. He has done well since with no recurrence of arrhythmia and he is acutely aware of when he goes into the fibrillation. He denies any shortness of breath, chest discomfort of congestive heart failure symptoms and has otherwise felt quite well. His only medication is the Lexapro 10 mg a day as an antidepressant and the Betapace. His review of systems is otherwise unchanged and negative.
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Considered an omission only if *both* experts identified it as an omission

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<thead>
<tr>
<th>Seriousness of omission</th>
<th>Both experts</th>
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<th>Percentage of documents</th>
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• Some omissions seem straightforward to remediate with easy changes to the EMR specification, e.g.
  – Negative patient reports (“denies SOB”)
  – Degrees for symptoms (“mild/severe pain”)
  – Reactions to allergies (“rash/hives”)
Results, disregarding “remediable” omissions

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• Other omissions seem difficult to remediate, even in principle
  – Nuanced/detailed elaborations
    • “almost brought to tears just in getting her up on the examination table”
    • “able to walk on flat levels and walk at a moderate pace for one hour without abnormal shortness of breath or chest pain”
• Other omissions seem difficult to remediate, even in principle
  – **Temporal/logical context**
    • ventricular tachycardia occurred “during post myocardial infarction care…far removed from the time of [patient’s] infarction”
    • the dictating physician was “hesitant to recommend [patient’s] FAA certification renewal” without a repeat of a previous catheterization
• Other omissions seem difficult to remediate, even in principle
  – Dictating physician’s thought process
    • recommends continuing Toprol because it “seems to be controlling [the patient’s] palpitations well”
    • considers discomfort to be “suggestive of angina”
    • believes that results of stress testing “would rule out significant major coronary artery disease, despite it being a somewhat incomplete study”
Difficult to remediate: the things that make the clinical narrative a *narrative*

“...As EMRs proliferate, and increased Medicare scrutiny looms, medical documentation is evolving from its original goal of recording what actually was going on with a patient, and what the provider was actually thinking, to sterile boilerplate documents designed to justify the highest billing codes.


*If you lose the language, you lose the story.*
There’s another reason the language of the clinical narrative is a big deal.
• The process of knowledge discovery is **a natural cycle**

• At every iteration, information emerges from data by **structuring** and categorizing the data according to what we know **now**

---

ORDER EXAM:
- MRI
- HD without and with IV gadolinium.

ORDER IND:
- Head
- H/o plasmacytoma
- MR head, without and with IV gadolinium.

Comparison is made with previous outside MR head examinations 5/3/04 and 11/16/04. On the earliest outside examination, there was a mass in the right central skull base, extending infratemporal fossa, sphenoid sinus, and foramen ovale. This subsequently was demonstrated to represent a plasmacytoma. This mass was reduced in size on the subsequent outside MR. Our current examination demonstrates peripheral enhancement, involving right clivus, right sphenoid, and base of right pterygoid. This mass is probably stable when compared with 11/16/04, but is considerably smaller than 5/3/04. The infratemporal soft tissue component of the lesion has resolved. No new or progressing bone lesion.

Incidental note is made of a small amount of hemosiderin deposition within the cortex of the left parietal operculum without abnormal enhancement. This could represent cryptic vascular malformation, or chronic lacunar infarct. Mild cerebral leukoaraiosis...
• The process of knowledge discovery is a natural cycle
• At every iteration, information emerges from data by structuring and categorizing the data according to what we know now
• As we improve our knowledge, those structures and categories change
If the full clinical narrative never comes into existence, the knowledge discovery cycle is broken.
Without the original data, we can never reanalyze physicians’ observations in the light of new knowledge and new categories.
Knowledge structures evolve slowly.

Clinical history:
- History of plasmacytoma (head)
- Mass in right central skull base
- Mass subsequently reduced in size

Findings:
- Abnormality in right central skull base...
- Mass smaller in size
- Mild cerebral leukoaraiosis

Current medications:
- Melphalan 9 mg/m² per day
- Prednisone 100 mg/day

Hypotheses:
- Cryptic vascular malformation
- Chronic lacunar infarct
Example: *ground glass opacity*

**Usage Period:** term emerged with the introduction of 64-slice CT scans *around 1991*.

**Definition:** a hazy increase in lung attenuation through which pulmonary vessels may still be seen.

**Clinical relevance:** evidence that these are a much more probable indication of lung cancer than fully solid or fully non-solid nodules.

**Appearance in standardized nomenclatures:** MedDRA, *in 2001*.

A dilemma

• The future of healthcare depends on structured information we can aggregate and analyze.

• EMRs are widely viewed as the way to get there.

• But typical EMRs threaten to
  – eliminate or fragment crucial language in the record
  – omit information that clinicians need in order to communicate effectively
  – destroy the knowledge discovery cycle
Natural language processing (NLP) technology offers a way out of the dilemma.
ORDER_EXAM: MRI Hd wo&w ORDER_IND: head - h/o plasmacytoma^ MR head, without and with IV gadolinium. Comparison is made with previous outside...
ORDER_EXAM: MRI Hd wo&w ORDER_IND: head - h/o plasmacytoma^ MR head, without and with IV gadolinium. Comparison is made with previous outside...
HPI: Atrial fibrillation. This patient is a 56-year-old white gentleman who has had a history of atrial fib on and off since he had his bypass surgery. Patient was originally diagnosed with coronary artery disease as well as mitral valve problems approximately 3 years ago. Dr. Tirona used to take care of him at that time. He had a bypass surgery as well as mitral valve repair done at that time. Postop he had an episode of A-fib which then resolved spontaneously. He remembers somebody talking to him about cardioversion, but then the A-fib resolved spontaneously. So he was started on Coumadin. He would get some occasional episodes, but usually they are very brief, so he never bothered about them. Of late, over the last few months, he has been getting more frequent episodes and duration of these episodes is also prolonged for a few hours. So he saw Dr. who has referred him here for further evaluation and treatment. The patient states when he does get the A-fib, he feels very weak, tired, and short of breath. He denies any chest pain. Otherwise he is usually very active physically, he works fulltime as an electrician, and has not had any problems as far as doing his day-to-day work.


PAST SURGICAL HISTORY: Significant for hernia repair and appendectomy.

ALLERGIES: Morphine. MEDICATIONS: Toprol-XL 100 daily. Vytorin 10/40 one tablet daily. Coumadin as directed.

SOCIAL HISTORY: Smokes occasionally. Drinks alcohol very occasionally. Married, has 2 children.

FAMILY HISTORY: Father died from an MI. Mother died from lung cancer. One brother alive. He has had a history of a lung mass resected which was noncancerous. Another brother is alive and healthy.

ROS: Otherwise unremarkable. EXAM: GENERAL: He is alert and comfortable.


HEENT: Pupils equal, reacting to light normally. Examination of the oral cavity is normal.

NECK: Good carotid upstroke bilaterally. No JVD.

CARDIAC: First and second sounds heard. Regular rate and rhythm. No gallops or murmurs.

ABDOMEN: Soft, nontender. No organomegaly.

DATA: Lab tests that are available reveal INR is therapeutic at 2.2. Chemistries are overall within the normal range. HDL cholesterol, however, is low at 34. LDL is 70.

IMPRESSION: Paroxysmal atrial fibrillation in a patient with prior mitral valve disease, currently having more frequent breakthroughs symptoms.

PLAN: I had a long discussion with the patient about the different treatment options including taking medications versus going for an ablation procedure. I did talk to him about the side effects of the antiarrhythmic drugs. Patient is somewhat leery of going on stronger medications. He wants to wait and see for awhile and if his symptomatology gets really bad, then he would be willing to consider more powerful medications. I do agree with him on that. Patient has not had any workup or any kind of a screening since he had his bypass surgery. So we will schedule him for exercise stress echo in the near future. With that information, if he does decide to go on antiarrhythmic drugs, then we can comfortably use class 1A or class 1C agents. Thank you for the consultation. We will keep you informed of the patient's progress.
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IMPRESSION: Paroxysmal atrial fibrillation in a patient with prior mitral valve disease, currently having more frequent breakthroughs symptoms.
Morphological analysis

Mrs. Roe is a 57-year-old female who has been having chest pains which she describes as a sharp pain, located substernally occurring at night when she tries to lie on her right side.

\[ \text{pains} = \text{pain} + \text{PLURAL} \]

In this context, \( \text{pains} \) is the same as \( \text{pain} \).

Sometimes singular vs. plural matters, e.g. \( \text{cyst} \) is different from \( \text{cysts} \).
Approaches to identifying/combining information units

57-year-old female who has been having chest pains which she describes as a sharp pain, located substernally
HPI: Atrial fibrillation. This patient is a 56-year-old white gentleman who has had a history of atrial fib on and off since he had his bypass surgery. Patient was originally diagnosed with coronary artery disease as well as mitral valve problems approximately 3 years ago. Dr. Tirona used to take care of him at that time. He had a bypass surgery as well as mitral valve repair done at that time. Postop he had an episode of A-fib which then resolved spontaneously. He remembers somebody talking to him about cardioversion, but then the A-fib resolved spontaneously. So he was started on Coumadin. He would get some occasional episodes, but usually they are very brief, so he never bothered about them. Of late, over the last few months, he has been getting more frequent episodes and duration of these episodes is also prolonged for a few hours. So he saw Dr. Hagan who has referred him here for further evaluation and treatment. The patient states when he does get the A-fib, he feels very weak, tired, and short of breath. He denies any chest pain. Otherwise he is usually very active physically, he works fulltime as an electrician, and has not had any problems as far as doing his day-to-day work.


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**IMPRESSION:** Paroxysmal atrial fibrillation in a patient with coronary artery disease and mitral valve problem currently having more frequent breakthroughs symptoms.

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**Type** | **Anatomy** | **Modifier** | **Diagnosis/Problem**
--- | --- | --- | ---
427.31 | atrial | - | fibrillation
427.31 | history | atrial | fibrillation
- | mitral_valve | - | problem
- | - | weak
- | - | tired
- | - | short_of_breath
414.01 | history | coronary_artery | disease
401.9 | history | - | hypertension
272.0 | - | - | hypercholesterolemia
427.31 | atrial | paroxysmal fibrillation
394.9 | history | mitral_valve | disease
HPI:
The patient presents with headache and pt here with head injury-- jumped and hit head on beam. + LOC, no neck pain, no numbness, visual changes, no vomiting, bleeding controlled at this time. No other injuries. The course/duration of symptoms is constant. Location: occipital. Radiating pain: none. Character of symptoms is throbbing. Associated symptoms: none.

MEDICAL HISTORY:
Medical history: Negative. Surgical history: Negative.

SOCIAL HISTORY:

ROS:
 Constitutional symptoms: Negative except as documented in HPI. Respiratory symptoms: Negative except as documented in HPI. Neurologic symptoms: Negative except as documented in HPI. Additional review of systems information: All other systems reviewed and otherwise negative.

EXAM:
Vital Signs: Heart Rate 73 bpm Respiratory Rate 14 breaths/min SBP NIBP 101 mmHg DBP NIBP 61 mmHg SpO2 99% General: No acute distress. Head: 5 cm laceration over top of head to sq. does not extend to galea. Neck: Supple, trachea midline, no tenderness. Neurological: Alert and oriented to person, place, time, and situation.
CHIEF COMPLAINT:
Right knee pain.

HISTORY OF PRESENT ILLNESS: The patient is a 61-year-old white female who works part-time at C... ...he said she developed sharp severe pain in her right knee beginning in November 2005. She did not have any injury that she knows of but now she is having increasing pain with walking, kneeling down and going up and down stairs. She had sharp severe pain in the medial compartment of her knee. She feels better when she is not moving at all.

PAST MEDICAL HISTORY:
Significant for hiatal hernia and a DVT in left upper extremity.

PAST SURGICAL HISTORY:
Significant for bilateral thoracic outlet surgery and left rib resection as well as a left knee arthroscopy.

CURRENT MEDICATIONS:
Include Crestor.

ALLERGIES:
Codeine, Salactif, iodine, sufa drugs.

FAMILY HISTORY:
Significant for heart disease, stroke, and osteoporosis.
IR D.O.B. [PHI REDACTED] Age: 37  
NAME: [PHI Redacted] D.O.B.: 2007-10-23 12:06:00 Gender: M  
SSN: [PHI Redacted] Attending: null  
Referred By: Signed By: null


Neurointerventional procedure

Cerebral angiogram, 4/24/2006

Indication: Spontaneous subdural hematoma

Physicians: 1. Dr. Joo


Discussion: Angiographic examination of the above vessels was performed after consent was obtained. A 5 French catheter was placed in the right common femoral artery, using the Seldinger technique, after Betadine prep and local anesthesia with lidocaine. After the procedure, the catheter was removed and hemostasis achieved at the puncture site.

Findings: Left internal carotid artery: There is subdural mass-effect over the left cerebral convexity manifest by displacement of pial vessels and cortical veins away from the inner table of the skull. There is rightward shift of the anterior cerebral artery complex. There are no arterial or venous vascular abnormalities.

Left external carotid artery: There are no dural vascular abnormalities.

Left vertebral artery: There is medial displacement of the left posterior cerebral artery complex. No vascular abnormalities are identified.

Right common carotid artery: There are no cerebral or dural vascular abnormalities.

Impression: Left convexity mass-effect consistent with known subdural hematoma. Negative cerebral angiogram.
Natural language processing and machine learning

Clinical data

Subject matter expertise
# NLP-enabled aggregate analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>Sample Measures</th>
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<tbody>
<tr>
<td>(A) Patient Identification &amp; Recruitment</td>
<td>Male smokers, 50 y.o.+ with history of COPD and no history of lung cancer for enrollment in a clinical trial/study</td>
</tr>
<tr>
<td>(B) Performance &amp; Accreditation</td>
<td>Patients with diabetes and their most recent HbA1C&lt;9.0%</td>
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<tr>
<td>(C) Acute Care Management</td>
<td>% of patients aged 5-40y.o. with asthma prescribed an inhaled corticosteroid</td>
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<tr>
<td>(D) Chronic Care Management</td>
<td>% of patients with Rheumatoid Arthritis prescribed a DMARD</td>
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<tr>
<td>(E) Utilization</td>
<td>Hospital readmission rates within 30 days after discharge</td>
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## NLP-enabled aggregate analysis

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<td>(F) Complications &amp; Patient Safety</td>
<td>Urinary catheter removal on post-operative day 1 or 2</td>
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<tr>
<td>(G) Provider Profiling</td>
<td>% of primary care MDs not prescribing Beta-Blocker Rxs for patients with left sided heart failure (LVSD)</td>
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<tr>
<td>(H) Revenue Cycle Support &amp; Efficiency</td>
<td>Specialist referral rates outside of the physician group or network (i.e. leakage)</td>
</tr>
<tr>
<td>(I) Customized Applications</td>
<td>The number of patients with hypertension discharged from the hospital on &lt; 2 antihypertensive Rxs</td>
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We can get where we need to go without losing the language.
A way forward: recognizing that structured datasets ≠ structured input

Informed by the best current knowledge and data, language transforms clinical language into standardized, interoperable, available information.

Physicians focus on the care of the patient and communicate unimpeded, full, narrative clinical data.

Both health information technology and medical communities of practice inform, and are informed by, evolving medical knowledge.
Save the cheerleader, save the world
Save the **narrative**, save the world

**Thank you.**
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