Natural Language Processing of Electronic Health Records to Evaluate Pain Care Quality in the Veterans Health Administration

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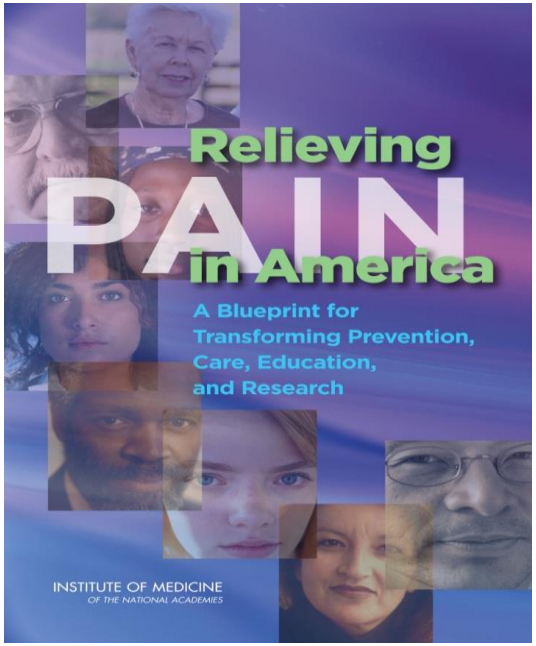
Care of People with Pain: Findings of the IOM

- **Pain care must be tailored to each person's experience**

- **Significant barriers to quality pain care exist**
  - Gaps in knowledge and competencies for providers
  - Magnitude of problem
    - Half of primary care providers report feeling only "somewhat prepared", 27% report feeling "somewhat unprepared" or "unprepared"
    - Inadequacies in subspecialty training
  - Systems and organizational barriers further complicate this picture



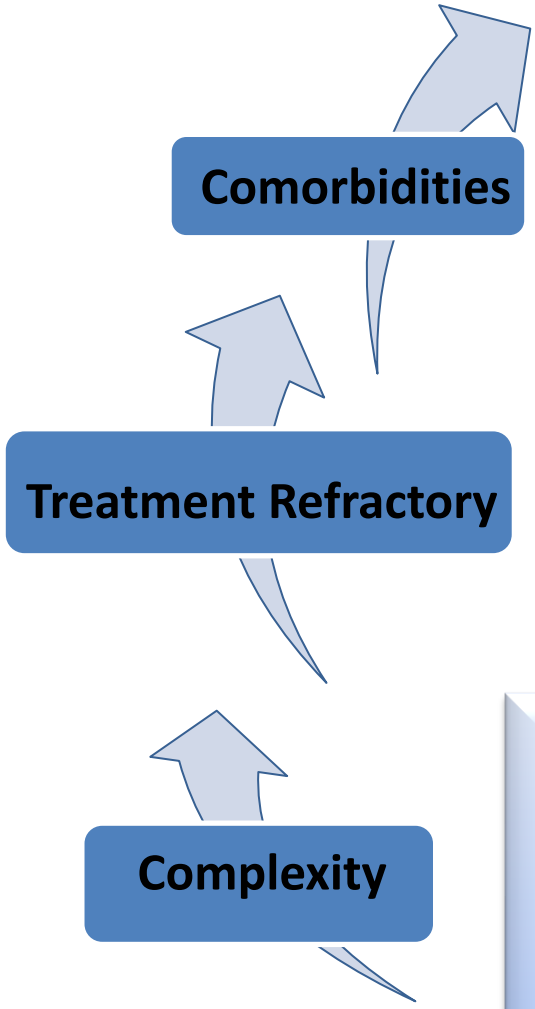
National Pain Management Strategy

Objective is to develop a comprehensive, multicultural, integrated, system-wide approach to pain management that reduces pain and suffering for Veterans experiencing acute and chronic pain associated with a wide range of illnesses, including terminal illness.

VHA Pain Management Directive

- Objectives of National Pain Management Strategy
- Pain Management Infrastructure
  - Roles and responsibilities
- Stepped Pain Care Model
- Pain Management Standards
  - Pain assessment and treatment
  - Evaluation of outcomes and quality
  - Clinician competence and expertise

Stepped Care Model for Pain Management



RISK

STEP 3

Tertiary Interdisciplinary Pain Centers
Advanced diagnostics & interventions
Commission on Accreditation of Rehabilitation Facilities accredited pain rehabilitation
Integrated chronic pain and Substance Use Disorder treatment

STEP 2

Secondary Consultation
Pain Medicine
Rehabilitation Medicine
Behavioral Pain Management
Interdisciplinary Pain Clinics
Substance Use Disorders Programs
Mental Health Programs

STEP 1

Primary Care/Patient Aligned Care Teams (PACTs)
Routine screening for presence & intensity of pain
Comprehensive pain assessment
Management of common acute and chronic pain conditions
Primary Care-Mental Health Integration, Health Behavior Coordinators, OEF/OIF/OND & Post-Deployment Teams
Expanded nurse care management
Clinical Pharmacy Pain Medication Management
Opioid Pain Care and Renewal Clinics

Project STEP
Program for Research Leadership
Donaghue Foundation and Mayday Fund

- Evaluate processes of implementation to determine best practice models for broader dissemination and implementation.
- Changes in group and organizational processes and evaluation of pain management and organizational outcomes are examined as the model is adopted.
- Qualitative and quantitative analysis will evaluate components of program implementation. Data will include administrative, outcome, and interview-based measures.

Sources of Data Collection

- Qualitative data from primary care providers and nursing staff, and specialists, regarding their experiences caring for patients with pain
- Manual extraction of indicators of quality of pain care from primary care provider progress notes
- Automated electronic health record and administrative data extraction examining key dimensions of pain care consistent with SCM-PM (e.g., guideline concordant care, opioid risk mitigation strategies)
  - Pain Cohort (moderate to severe pain)
  - Opioid Cohort (receipt of long term opioid therapy, i.e., >90 days)

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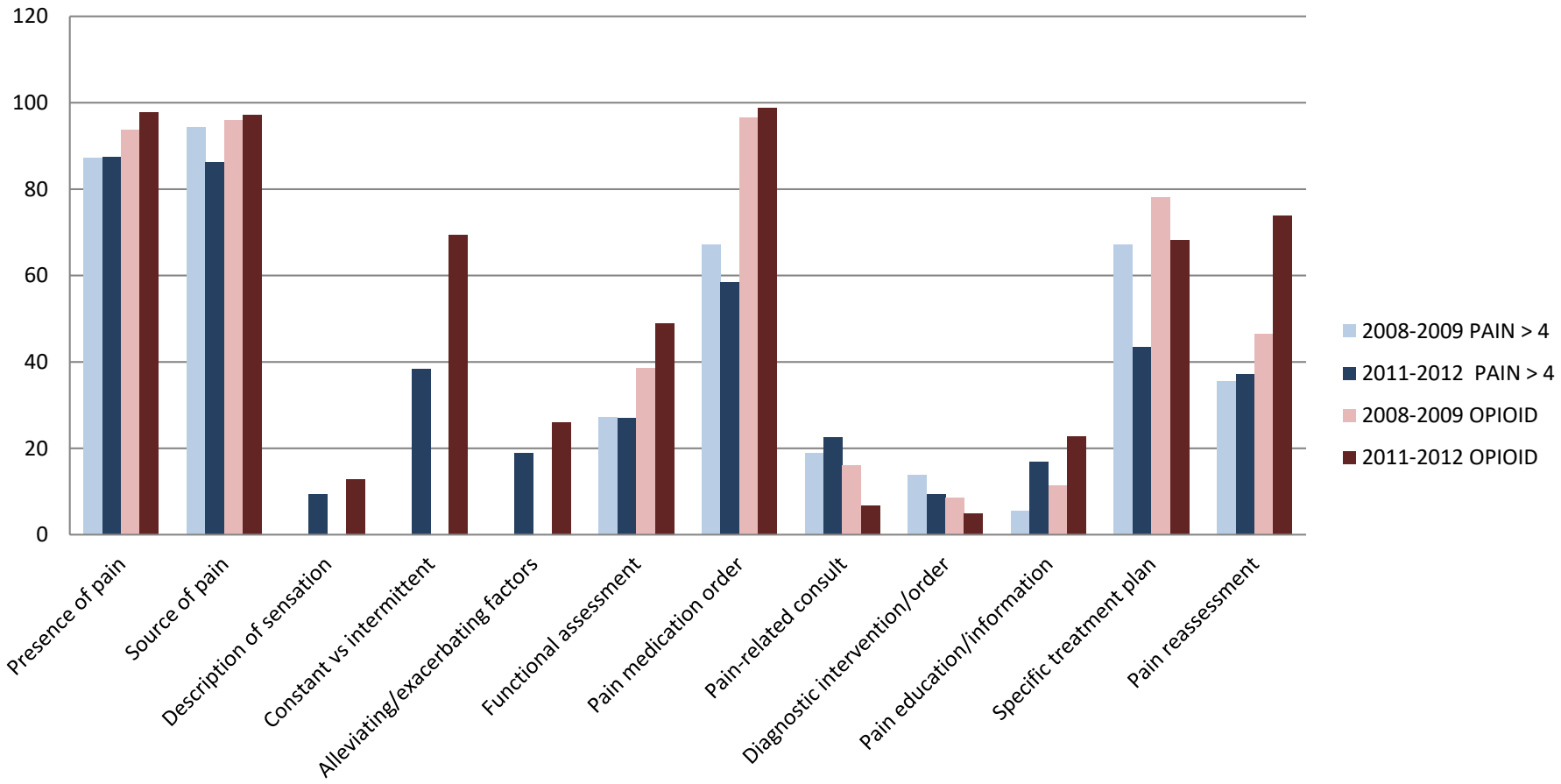
Quality of Care Data Extraction

- Examination of quality of care of chronic pain
  - Documentation of pain assessment, treatment planning, and reassessment (outcomes), and patient education
- Consistent with goals of VHA National Pain Management Strategy, which include continual monitoring and documentation of outcomes of pain treatment, and multifactorial assessment that includes:
  - Pain intensity
  - Pain interference
  - Physical capacities

Quality of Care Data Extraction

- Creation of data extraction tool
  - Quality of care coding tool developed through literature review and VA/DOD policies and guidelines, with input from pain mgmt providers
- Specific focus on pain assessment, treatment planning, and reassessment
- Coding manual defined with operational definitions
- Acceptable inter-rater reliability
  - (Cohen's kappa .78 -.91)

Manual Chart Extraction Data: Quality of Care Indices



Need for automated approach

- Manual extraction approach is resource and time intensive
- Precludes widespread adoption
- Development of an automated approach holds promise for improving reliability and scalability
- Potential for use in quality improvement initiatives

Natural Language Processing (NLP) Development and Application to A National Sample

First Step -Annotated Corpus

Random sample of patients - 64 males and 13 females from each station.
Total Male/Female: 8268/1672
Number of TIUs: 376,487
Unique Standard note Titles: 2172

Narrowed notes by stop codes (350,322,323) - Primary Care
Total TIUs: 138,274
Unique Standard Titles: 849

Further Narrowed to Physician/Provider Notes, with count pain score < 3
Remaining Note titles: 101
Number of remaining TIUs: 99,481.
Analytic Data Set.

Subset selected for Pass 1 annotation. Keeping all notes for each patient, 20 sets of approximately 100 notes each and two pilot sets of 50 notes were selected for annotation.

Pain Mention
Pain Etiology
Pain Site
Pain Diagnostics
Pain Intensity
Pain Persistence
Diurnal Variation
Aggravating Factors
Alleviating Factors
Functional Assessment
Pain Reassessment
Treatment (prelim)

Vocabulary from the preliminary Treatment annotations was used to select rich notes for Pass 2 annotation.
They were selected from the analytic cohort without regard for patient.
22 sets of 100 plus 2 pilot sets 0f 100

Used to select documents for Treatment annotations

Pass2 Treatment
Consult/Referral Action
Consult/Referral Discipline
Side Effects (as assertion)
Pharmacologic
Injections
Implantable
Assistive Device
CIH
Mental Health
Self-Management
Education Action
Education Topic
Chiropractic
Other
Pain Reassessment
Physical Diagnostic

From Corpus Vocabulary Development

Combined Annotations (89,000)

Final Vocabulary (> 16,000 terms)

Vocab Work
Extract all term/class pairs
Eliminate Duplicates
Clean extraneous artifacts
Check for class conflicts
Split/recode some spans (LVG)
Normalize

Original Span	Final Span
Just standing up from chair	standing up
Lifting and moving heavy boxes	lifting and moving heavy
Lying down increases	Lying down
Heat/cold for temporary relief	Heat/cold
Carisoprodol 350 mg	Carisoprodol

8	heat<--->Treatment	heat<--->Assess-Alleviators	F048374831--L534--N1200825860677
15	mild<--->Assess-Intensity	mild<--->Assess-Sensation	M992638627--L568--N1000234377378
10	standing<--->Assess-Aggravators	standing<--->Assess-Alleviators	M997972547--L664--N800430016381
5	strain<--->PainEtiology	strain<--->PainMention	F016100821--L540--N1400228093131
17	ibuprofen<--->Treatment	ibuprofen<--->Assess-Alleviators	F018187081--L516--N1200747160999
8	heat<--->SelfManagement	heat<--->Assess-Alleviators	F048374831--L534--N1200825860677

Basis for Rule Based Extraction

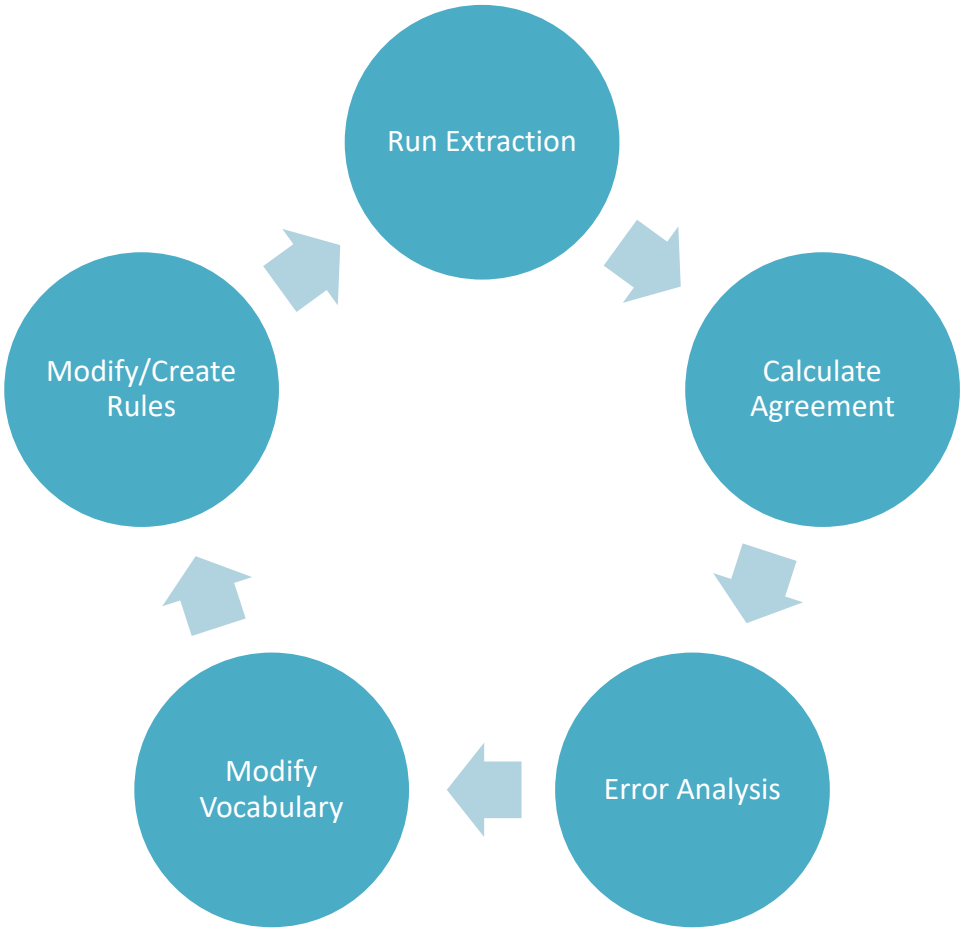
Steps For Rule Based Extraction
Extract raw annotations for each line
Construct a sequence of annotations based on offsets
Examine using rules to qualify pieces as final extractions
Check for any assertions that may apply (negation etc.)

Neck pain is controlled with accupuncture and methadone.

Site → PainMention → Sat → CIH → Pharm

Rule	Annotation
Site-PainMention	Site = Pain Site
Sat-CIH	Sat = Pain Reassessment
PainMention-Sat	Sat = Pain Reassessment
CIH	CIH = CIH
Pharm	Pharm = Pharm

Iterative Process



Results – Simple

Class	F Measure
PainMention	.968
Etiology	.943
Pharmacologic	.955
Diagnostic Image	.990
Assistive Device	.988
Surgical	.877
Treatment-Other	.891
CIH	.891
Injection	.901
Chiropractic	.928
Implantable	1.00
Mental Health	1.00

Results – Intermediate Rules

Class	Structure	Example	F Measure
Education	EducateVerb-Topic	Given education on fall prevention	.937
Pain Intensity	Pain-Intensity	Pain: 7 – pain is severe	.774 (numerical weak)
Pain Site	Pain-Site or Site-Pain	Hip pain	.872
Sensation	Pain-Sensation	Pain radiates	.866
Referral	ReferVerb-Discipline	Referred to Neurology	.964
Persistance	Persist-Pain	Chronic Pain	.827
Reassessment	Pain-(Imp,NoImp,Stable)	Pain has improved with	.802
Diurnal Variation	Pain-Diurnal	Pain is worse in the morning	

Results – Complex and Rare

- Not many instances found
- Many of the exact same text spans were annotated in all three classes
- Makes identifying them very dependent on context
- Cues were not originally annotated – derived afterwards
- Annotation dificult

Class	Structure	Example	F-Measure
SelfManagement	(Treatment)-SelfManagment	She uses massage therapy and exercise	.625
Aggravator	AggCue-Aggravator	What makes the pain worse: exercise	.635
Alleviator	Alleviator-AllCue	Exercise helps relieve the pain	.735

Overall Accuracy (F-Measure)

Pair-wise agreement

Gold standard set	compared set	true positives	false positives	false negatives	precision	recall	F-measure
Reference	TagLine	10341	784	1037	90.9%	93.0%	91.9%
TagLine	Reference	10341	1037	784	93.0%	90.9%	91.9%

Precision and recall are given equal weight for the F-score.

Application to National Sample

- All outpatient primary care provider visits/notes
  - Newly diagnosed with MSD
  - Pain intensity ratings >= 4/10 in FY 2013
- For each visit
  - A value of 1 or 0 was assigned to reflect evidence of documentation of each PCQI
  - Create a summative PCQ score
- PCQIs were also described as sub-groups
  - Pain Assessment
  - Plan of Care
  - Reassessment (a single Item)
- Common patient and facility characteristics were used to compare individual item and summative scores

Patient Characteristics	N	%
Age		
19-34	10,949	17
35-49	13,375	20.8
50-64	27,617	42.9
65-79	9,924	15.4
80+	2,579	2.4
Female	6,692	10.4
Non-white	12,594	19.5
Currently Married	32,438	50.3
Current Smoker	27,887	43.3
Obese (BMI $\geq$ 30.0)	29,017	45.0

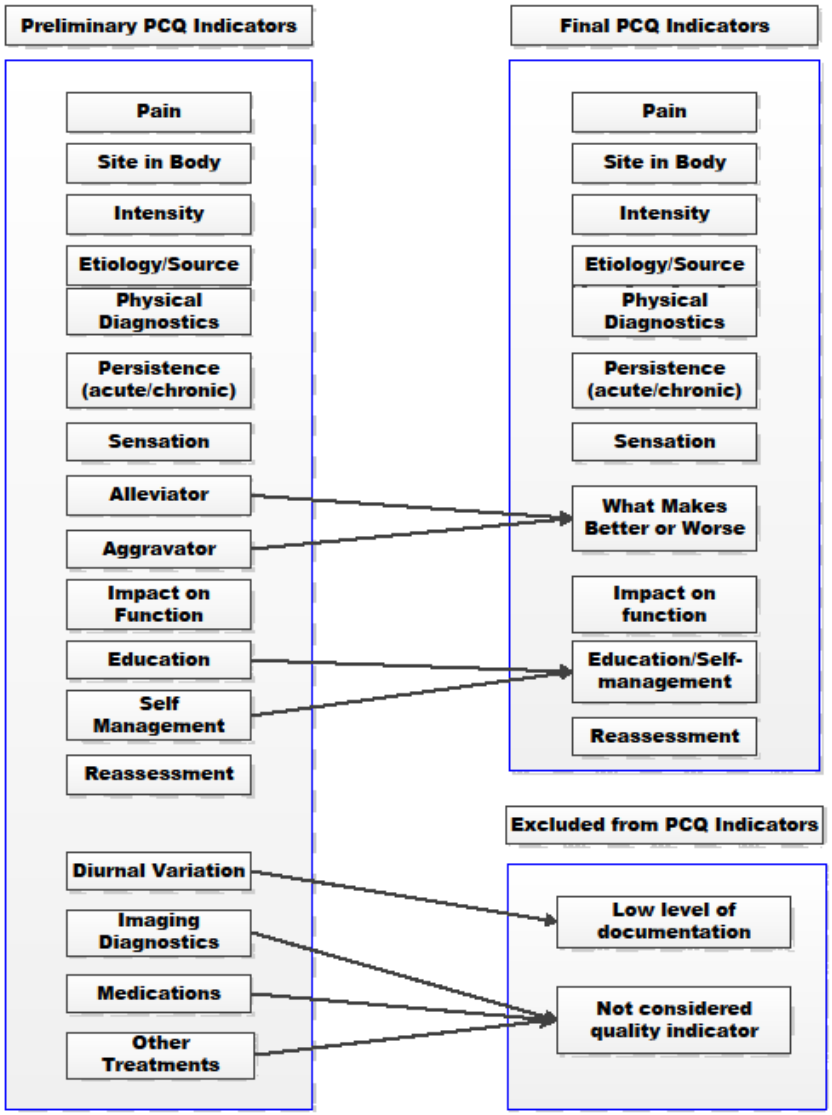
Documents from 64,940 Veterans were analyzed

Documents were from 130 VHA facilities, and 125,408 unique primary care visits.

Facility Characteristic	Visits	%
Facilities (n=135)	125,408	100
Facility Complexity		
1a	56,725	45.2
1b	24,893	19.9
1c	16,739	13.3
2	15,128	12.1
3	11,784	9.4
Primary Stop Code		
Primary Care/Medicine	119,977	95.6
Comp Women's Health	4,816	3.9
Geri PACT	615	0.04

Refine Indicators

- Combine Alleviators and Aggravators
- Combined Educations and Self Management
- Dropped Diurnal Variation
- Dropped Imaging, Medications.

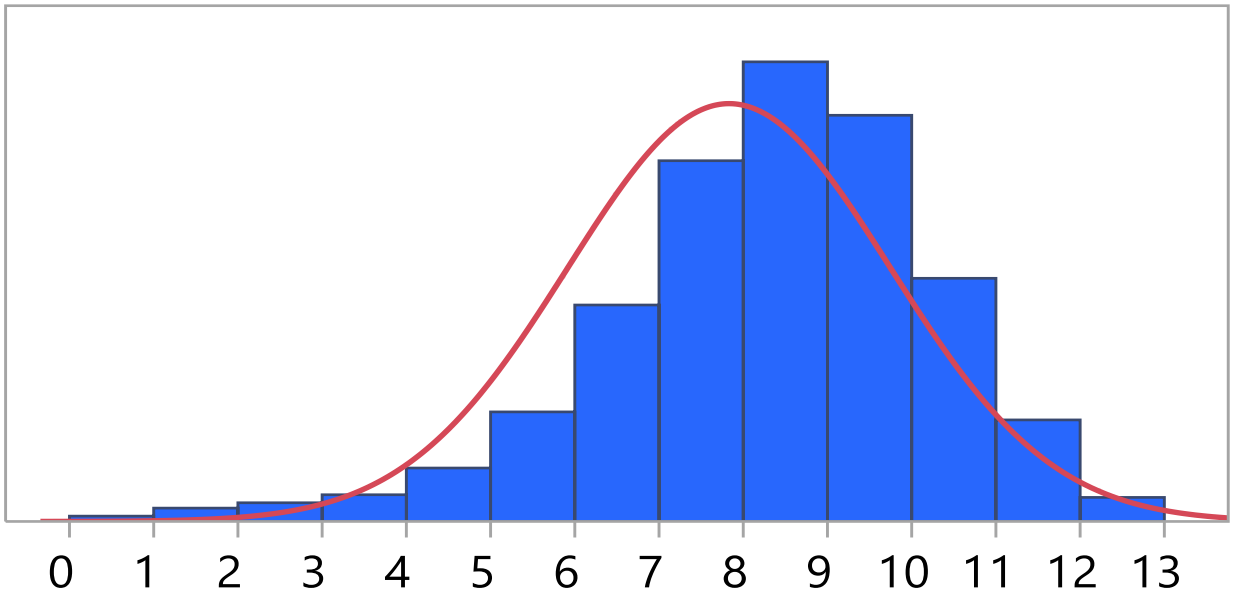


The most documented PCQI measures by visit were related to Presence of Pain.

The least commonly documented related to Impact on Function.

Indicator by Visit		
Pain Care Quality Indicator	**Visit**	**%**
Assessment of Pain		
Pain	122,198	97.4
Site in body	113,256	90.3
Etiology/source	118,068	94.1
Physical diagnostics	111,490	88.9
Intensity	81,869	65.3
Persistence (e.g., acute/chronic)	52,425	41.8
Sensation (e.g., pain radiates)	39,199	31.3
What makes pain better or worse	27,750	22.1
Impact on function	21,102	16.8
Plan of Care		
Referral	102,313	81.6
Education/Self-management	92,733	73.9
Reassessment		
Reassessment	99,575	79.4

Mean score of the PCQI measures was 7.8 out of a possible 12.



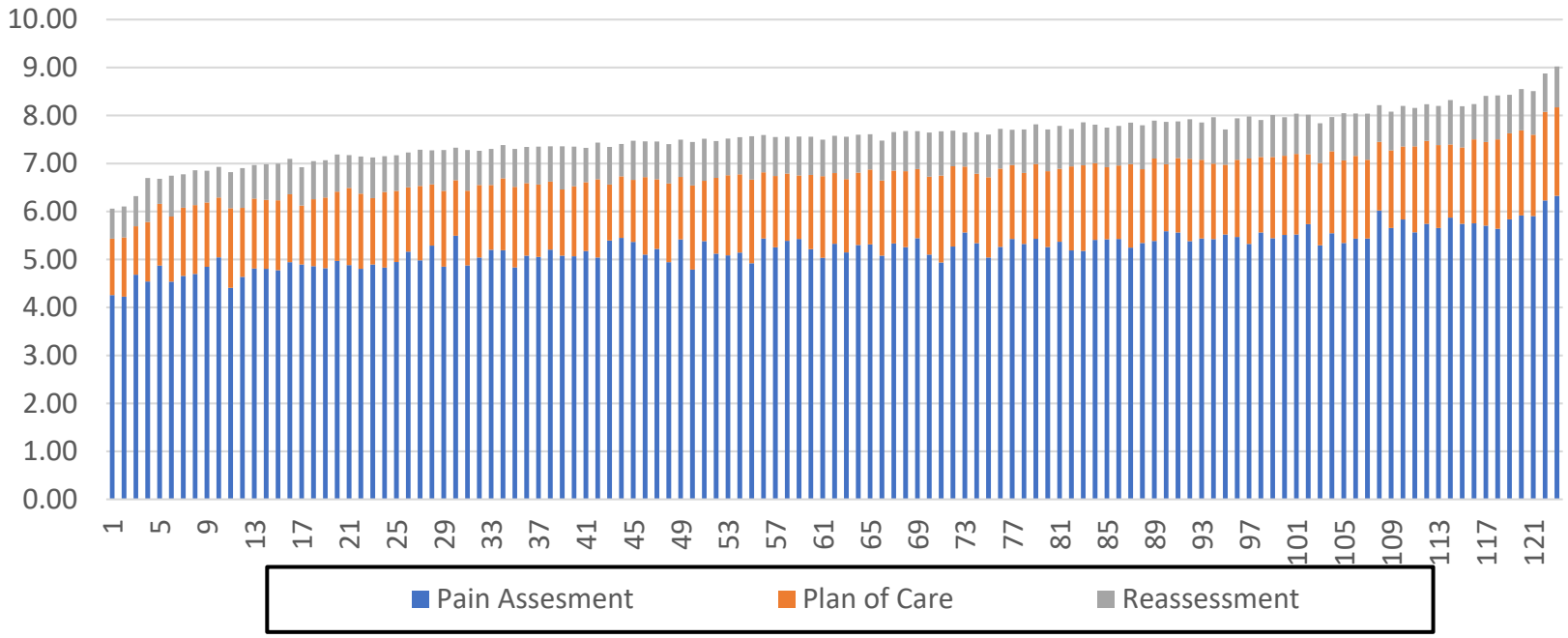
Patient Characteristic and Mean PCQ Indicator Total Score

Patient Characteristics	N Patients (%)	N Visits (%)	PCQ Score Mean (SD) Per Visit
Age			
19-34	10,949 (17.0)	21,125 (16.9)	8.0 (2.0)
35-49	13,375 (20.8)	26,882 (21.4)	8.0 (1.9)
50-64	27,617 (42.9)	55,898 (44.6)	7.8 (1.9)
65-79	9,924 (15.4)	17,236 (13.7)	7.6 (1.9)
80+	2,579 (2.4)	4,267 (3.4)	7.4 (1.9)
Gender			
Female	6,692 (10.4)	14,182 (11.3)	7.8 (1.9)
Male	57,752 (89.6)	111,226 (88.7)	7.9 (1.9)
Race			
Non-white	12,594 (19.5)	43,855 (35.0)	7.8 (1.9)
White	51,850 (80.5)	81,553 (65.0)	7.9 (1.9)
Marital Status			
Currently Married	32,438 (50.3)	61,695 (49.0)	7.9 (1.9)
Currently Un-married	32,006 (49.7)	61,713 (51.0)	7.8 (1.9)
Smoking Status			
Current Smoker	27,887 (43.3)	56,451 (45.0)	7.9 (1.9)
Current Non-smoker	35,667 (55.4)	63,636 (50.7)	7.9 (1.9)
Unknown	880 (1.3)	5,321 (4.2)	8.0 (1.9)
Obesity			
Obese (BMI >= 30)	29,017 (45.0)	57,345 (45.7)	7.9 (1.9)
Not Obese	35,541 (55.1)	66,664 (53.2)	7.8 (1.9)
Unknown	2,886 (4.5)	1,399 (1.1)	7.8 (1.9)

Percent Documentation and Mean PCQ Indicator Total Score by Facility Characteristic and Clinic Type

Facility Characteristics	Number of Visits (%)[2]	PCQ Indicator Score Mean (SD)
Facility Complexity		
1a	56,725 (45.2)	7.9 (1.9)
1b	24,893 (19.9)	7.8 (1.9)
1c	16,139 (13.3)	7.6 (2.0)
2	15,128 (12.1)	7.6 (1.9)
3	11,784 (9.4)	7.6 (1.9)
Primary Stop Code		
Primary Care/Medicine	111,997 (95.6)	7.8 (1.9)
Comp Women's Health	37,990 (3.9)	7.9 (1.9)
Geriatric Patient Aligned Care Teams	4,822 (0.5)	7.8 (2.2)
1. Facilities, n= 130 **2. Visits, n = 124,408**		

Variation Across Facilities



Conclusion

- Can use NLP to identify and quantify empirically-derived, key dimensions of Pain Care Quality
  - Some rarely used and complexed concepts are targets for improved measurement.
- Pain Care Quality Measures are well documented and appear to be consistently applied across patient and facility-level characteristics.
- The method can be used to assess factors associated with Pain Care Quality .

Association of Mental Health Diagnoses with Indicators of Pain Care Quality in Primary Care

Spotlight on Pain Management CyberSeminar: Natural Language Processing of Electronic Health Records to Evaluate Pain Care Quality in the Veterans Health Administration

May 4, 2021

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Background

- Mental health conditions are common among individuals with chronic pain and associated with worse outcomes
- Mechanisms may include:
  - Direct effects on shared functional outcomes
  - Shared psychological mechanisms (e.g., catastrophizing)
  - Shared neural mechanisms
- Another possibility: Disparities in pain treatment
  - Barriers to accessing high quality care
  - Decreased patient adherence to care
  - Competing demands on clinicians to address multiple conditions

Bair 2003; Linton 2011; Hooten 2016

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Objective

- Utilize data on pain care quality from cohort to determine to what extent mental health diagnoses are associated with indicators of pain care quality, as documented by VHA clinicians.

- Hypothesis: Mental health conditions will be negatively associated with total Pain Care Quality (PCQ) scores.

Methods

- Mental health diagnosis categories
  - PTSD
  - Bipolar Disorder
  - Schizophrenia/schizophreniform
  - Depressive disorders (other than bipolar disorder)
  - Alcohol use disorders (AUD)
  - Substance use disorders (other than AUD)
  - Anxiety disorders
- Analysis:
  - Generalized estimating equations used to examine longitudinal association among mental health diagnosis categories and PCQ scores over 12 months
  - Built series of models adjusting for demographic/clinical variables and within-subject PCQ scores over time
  - Conducted several sensitivity analyses

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Outcome: Composite PCQ score

The 12 Pain Care Quality Indicator Categories

Pain Assessment

Pain
Site in Body
Intensity
Etiology/Source
Physical diagnostics (exam)
Persistence
Sensation
Aggravators or Alleviators
Impact on function

Plan of Care

Referral
Education/Self-management

Reassessment

Reassessment

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Cohort characteristics: mental health diagnoses

Diagnosis category	Overall sample N=64,444	Within Mental Health Diagnosis group N=29,386
PTSD	18.3%	40.0%
Alcohol Use Disorder	11.2%	24.6%
Drug Use Disorder	5.9%	12.8%
Bipolar Disorder	4.6%	10.0%
Depression	27.3%	60.0%
Anxiety	14.2%	31.2%
Schizophrenia	1.1%	2.4%

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Other cohort characteristics

Characteristics by domain	Has Mental Health Diagnosis N=29,386	No Mental Health Diagnosis N=35,058	P value
Age (yr)	49.4±14.7	56.1±15.5	<0.001
Female	12.8%	8.4%	<0.001
Non-White race/ethnicity	34.9%	35.5%	0.10
Currently married	46.3%	53.8%	<0.001
Current smoker	51.4%	36.4%	<0.001
Body Mass Index (BMI)	29.8±6.2	30.4±6.1	<0.001
Service in recent military conflicts	23.8%	11.8%	<0.001
Back pain	2721 (9.3%)	2472 (7.1%)	<0.001
Neck pain	2863 (9.7%)	2755 (7.9%)	<0.001
Low back pain	9778 (33.3%)	10172 (29%)	<0.001
Fibromyalgia	592 (2.0%)	412 (1.2%)	<0.001
Fracture	905 (3.1%)	830 (2.4%)	<0.001
Osteoporosis	117 (0.4%)	185 (0.5%)	0.02
Non-traumatic joint damage	10674 (36.3%)	12778 (36.5%)	0.70
Sprains/strains	887 (3.0%)	1084 (3.1%)	0.60
Gout	667 (2.3%)	1337 (3.8%)	<0.001
Traumatic joint/muscle/spinal cord	764 (2.6%)	797 (2.3%)	0.007
Rheumatic-/osteoarthritis	3233 (11.0%)	5383 (15.4%)	<0.001

GEE models of PCQ score (n=64,444 Veterans)

Model	Diagnosis Category	RR*	Lower limit 95% CI	Upper Limit 95% CI	P value
1: Includes only single diagnosis category as predictor					
	PTSD	1.018	1.014	1.022	<.001
	Depression	1.024	1.020	1.027	<.001
	AUD	1.003	0.998	1.008	.03
	SUD	0.993	0.986	1.000	.04
	Schizophrenia	0.952	0.933	0.972	<.001
	Bipolar disorder	0.993	0.986	1.001	.08
	Other anxiety	0.957	0.941	0.973	<.001
2: Includes all 7 diagnosis categories simultaneously					
	PTSD	1.011	1.007	1.015	<.001
	Depression	1.022	1.018	1.026	<.001
	AUD	1.001	0.995	1.007	.76
	SUD	0.986	0.979	0.994	<.001
	Schizophrenia	0.960	0.944	0.976	<.001
	Bipolar disorder	0.990	0.982	0.998	.01
	Other anxiety	1.004	0.999	1.009	.14
3: Full model adds more demographic/clinical and facility variables					
	PTSD	1.003	0.999	1.008	.14
	Depression	1.017	1.013	1.021	<.001
	AUD	1.006	1.001	1.012	.03
	SUD	0.985	0.977	0.992	<.001
	Schizophrenia	0.970	0.954	0.985	<.001
	Bipolar disorder	0.988	0.981	0.996	.002
	Other anxiety	0.998	0.993	1.002	.30

Full model

Diagnosis category	Relative risk	Lower Limit CI	Upper Limit CI	P value
PTSD	1.003	0.999	1.008	.14
Depression	1.017	1.013	1.021	<.001
AUD	1.006	1.001	1.012	.03
SUD	0.985	0.977	0.992	<.001
Schizophrenia	0.970	0.954	0.985	<.001
Bipolar disorder	0.988	0.981	0.996	.002
Other anxiety	0.998	0.993	1.002	.30

Full model

Diagnosis category	Relative risk	Lower Limit CI	Upper Limit CI	P value
PTSD	1.003	0.999	1.008	.14
Depression	1.017	1.013	1.021	<.001
AUD	1.006	1.001	1.012	.03
SUD	0.985	0.977	0.992	<.001
Schizophrenia	0.970	0.954	0.985	<.001
Bipolar disorder	0.988	0.981	0.996	.002
Other anxiety	0.998	0.993	1.002	.30

- Takeaways:
  - SUD and schizophrenia associated with lower PCQ scores
  - Depression associated with *higher* PCQ scores
  - Differences not large

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Findings for schizophrenia and SUD not that surprising

- Multiple studies have shown patients with serious mental illnesses may not access or do not have access to care for comorbid conditions
- Redelmeier et al (1998) found that older individuals with psychotic disorders were 41% less likely to receive treatment for arthritis
- Cognitive or communication challenges?
- A few older studies suggest that *some* patients with schizophrenia have high pain thresholds—does this influence practice?
- Barriers to pain care among individuals with SUD shown to include:
  - Decreased follow-up with recommendations and referrals
  - Increased misuse or diversion of opioids
  - Decreased satisfaction with pain treatment
- Individuals with both conditions may be less likely to have regular primary care and to receive preventive care

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Why would depression be associated with higher pain quality scores?

- Providers may be aware of relationship of depression to chronic pain
- Patients with chronic pain often receive antidepressants (which may lead to increased diagnosis)
- Patients with depression may be more apt to communicate including about somatic symptoms

Limitations

- Although statistically significant, it is unclear how clinically significant these findings are
- Does not provide information about mechanisms
- Some diagnoses (anxiety) may be under-coded
- Unclear generalizability to other populations
- Summary score of PCQ may not be best measure (e.g., we did not weight individual components)