



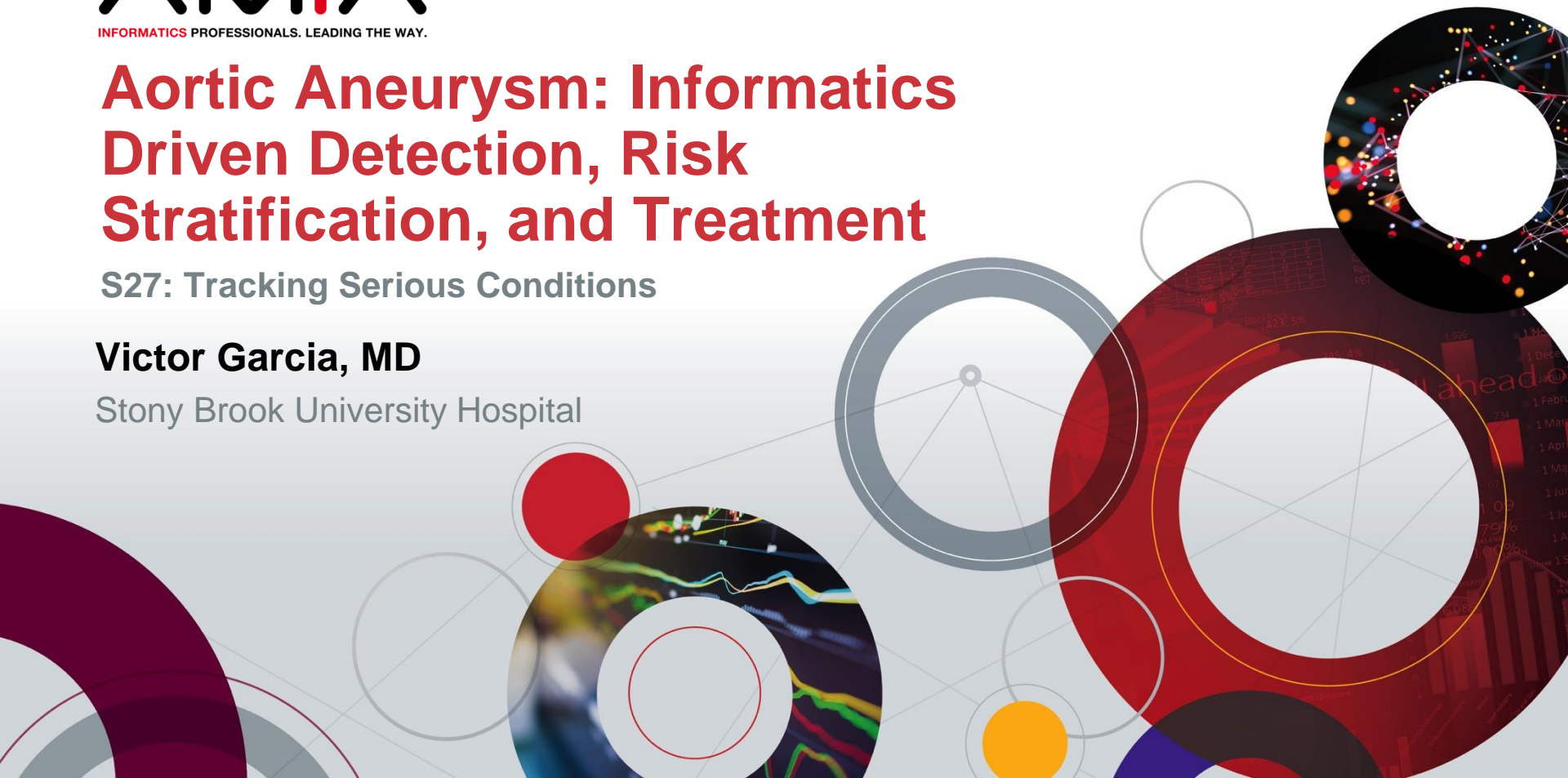
INFORMATICS PROFESSIONALS. LEADING THE WAY.

# Aortic Aneurysm: Informatics Driven Detection, Risk Stratification, and Treatment

S27: Tracking Serious Conditions

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Stony Brook University Hospital



# Disclosure

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We have no relevant relationships with commercial interests to disclose.

# Learning Objectives

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After participating in this session the learner should be better able to:

- Create a workflow to identify disease states from radiology reports
- Learn which tools and processes can be used in this process
- Anticipate potential challenges when implementing this workflow in their institution

# Problem Addressed

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An aneurysm is a dilated vessel

Most aneurysms grow without producing symptoms, and once they exceed a critical size threshold, their risk of rupture increases exponentially

A ruptured abdominal aortic aneurysm (AAA) has an 80% mortality<sup>1</sup>

Elective repair of an AAA has a perioperative mortality of 1.2-3.2%<sup>2</sup>

Aortic aneurysms can be discovered incidentally during imaging studies yet lost to follow-up<sup>3</sup>

of incidentally found AAAs only 29% are mentioned in the progress notes and 26% in the discharge summaries

We created a system to identify patients with aortic aneurysm and facilitate their outpatient follow-up

# Project Overview

Notes extracted  
from EHR



Data stored in  
searchable database



**Elasticsearch**

Store, search, analyze



**Kibana**

Visualize, navigate, share

Clinical review  
and outreach



# Prior departmental work

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Previously, the Department of Vascular Surgery attempted to identify patients at risk of having aortic aneurysms

A manually curated dataset was created with patients at risk of having an aortic aneurysm

The dataset contained labelled data, such as presence of comorbidities, aorta size, and presence of thoracic and abdominal aortas

This dataset was our ground truth

# Screening Recommendations

## United States Preventative Services Task Force (USPSTF)<sup>4</sup>:

Men aged 65 to 75 years who have ever smoked	The USPSTF recommends 1-time screening for abdominal aortic aneurysm (AAA) with ultrasonography in men aged 65 to 75 years who have ever smoked.	<b>B</b>
Men aged 65 to 75 years who have never smoked	The USPSTF recommends that clinicians selectively offer screening for AAA with ultrasonography in men aged 65 to 75 years who have never smoked rather than routinely screening all men in this group. Evidence indicates that the net benefit of screening all men in this group is small. In determining whether this service is appropriate in individual cases, patients and clinicians should consider the balance of benefits and harms on the basis of evidence relevant to the patient's medical history, family history, other risk factors, and personal values.	<b>C</b>

## Society for Vascular Surgery (SVS)<sup>5</sup>:

We recommend a one-time ultrasound screening for AAAs in men or women 65 to 75 years of age with a history of tobacco use.

Level of recommendation	1 (Strong)
Quality of evidence	A (High)

We suggest a one-time ultrasound screening for AAAs in men or women older than 75 years with a history of tobacco use and in otherwise good health who have not previously received a screening ultrasound examination.

Level of recommendation	2 (Weak)
Quality of evidence	C (Low)

# Aorta Measurements

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Based on the SVS criteria and established by our clinical expert

Ascending aorta:

Diameter <40mm: Normal

Diameter 40-45mm: Ectasia

Diameter >45mm: Aneurysm

Abdominal aorta:

Diameter up to 24mm: Normal

Diameter 25mm-29mm: Ectasia

Diameter >30mm : Aneurysm

Descending aorta:

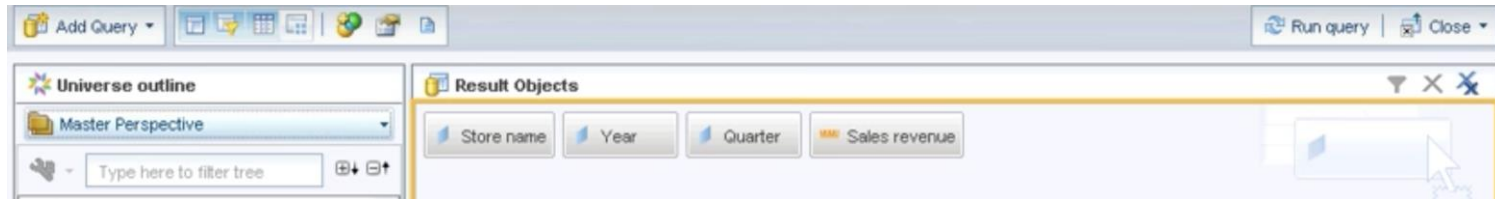
Diameter < 30mm : Normal

Diameter: 30-40mm: Ectasia

Diameter > 40mm: Aneurysm

# Data Extraction Selection Criteria

- Patients  $\geq 60$  yrs who have ever smoked
- Have presented to Stony Brook within the specified time frame
- Had an imaging study identified by CPT code
  - CT scan, Abdominal Ultrasound, Arterial duplex
- With no history of aneurysm repair noted by CPT code



SQL

# Smoking History

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- Nursing Questionnaire
  - Heavy tobacco smoker
  - Former smoker
  - Light tobacco smoker
  - Smoker (current status unknown)
  - Current some day smoker
  - Current every day smoker
  - Current (some day smoker)
  - Smoker, current status unknown
  - Light Tobacco Use ( <5 cigarettes/day)
- ICD Codes
  - F17.2 Nicotine dependence
  - Z87.891 History of nicotine dependence
  - Z72.0 Tobacco use
  - T65.2 Toxic effects of tobacco and nicotine
  - F17 Nicotine dependence

# From Reporting Tool to SQL

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1. Reproduce the BusinessObject Web Intelligence query that produced the original ground truth patient cohort
  1. Uses the Stony Brook Registries Population
  2. Encountered issues when re-running the query
2. Recreate query structure with SQL for future queries

# Notes Database

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Extracted notes were uploaded to a server behind the university firewall

To query and explore the corpora, we used Elasticsearch search engine coupled with the Kibana visualization tool

Elasticsearch<sup>6</sup>

JSON-based RESTful search engine for both structured and unstructured data

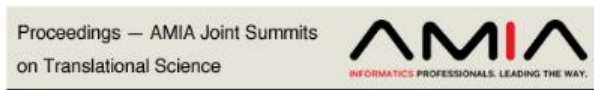
Allowed us to identify parsed strings in multiple files in the dataset

Kibana<sup>7</sup>

Allowed for graphical representation and exploration of our results

# Developing the Query

Took inspiration from work by Sohn, et al.<sup>8</sup>

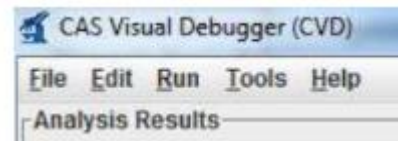


[AMIA Jt Summits Transl Sci Proc.](#) 2013; 2013: 249–253.

PMCID: PMC3845740

Published online 2013 Mar 18.

PMID: [24303276](#)



## Identifying Abdominal Aortic Aneurysm Cases and Controls using Natural Language Processing of Radiology Reports

[Sung-hwan Sohn](#), PhD, <sup>1</sup> [Zi Ye](#), MD, PhD, <sup>2</sup> [Hongfang Liu](#), PhD, <sup>1</sup> [Christopher G. Chute](#), MD, DrPH, <sup>1</sup> and [Iftekhar J. Kullo](#), MD <sup>2</sup>

Table 2. AAA related keywords (normalized through LVG)

AA	AAA	S/P	Normal
infrarenal aorta abdominal aorta aorta abdominal infrarenal location	a.a.a. abdominal aortic aneurysm aneurysm abdominal aorta aneurysm abdominal aneurysm abdominal aortic aorta abdominal aneurysm aortic aneurysm abdominal infrarenal abdominal aorta infrarenal aortic aneurysm	post a.a.a. repair s/p a.a.a. repair endograft endovascular aneurysm sac bifurcate endograft endoleak	normal caliber abdominal aorta normal distal aorta abdominal aorta normal caliber aorta normal caliber

# Using the Ground Truth Dataset

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Dataset of 2033 patients with 293 having either a TAA or AAA

Notes extracted from EHR into repository

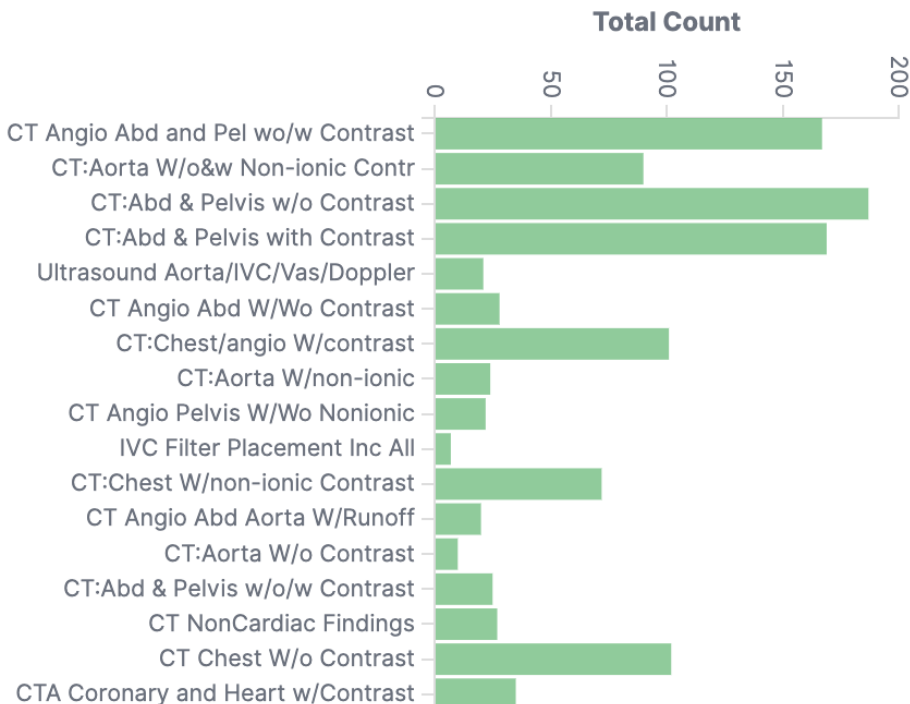
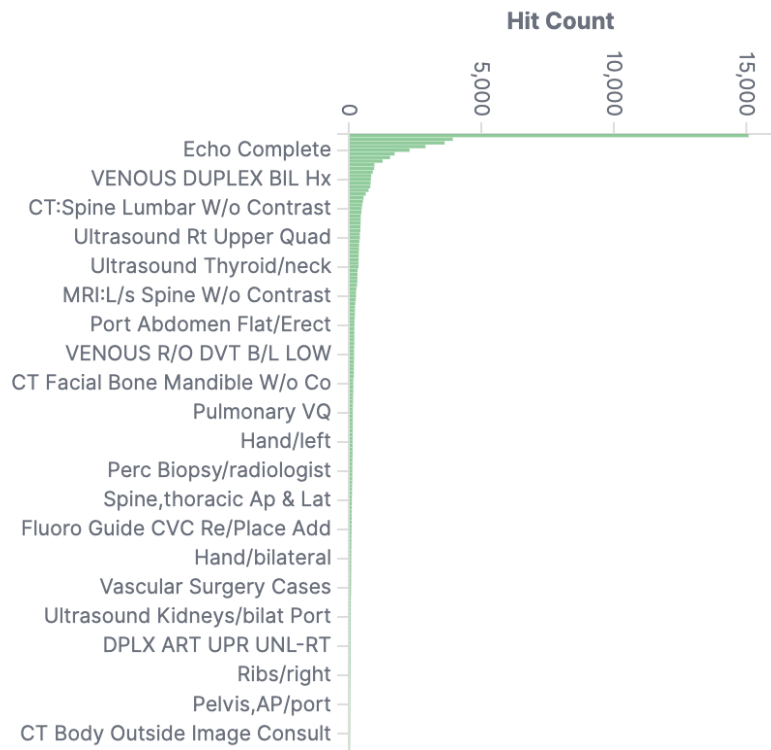
Reports reviewed and strings of interest extracted

Compiled a list of strings and tested in Elasticsearch

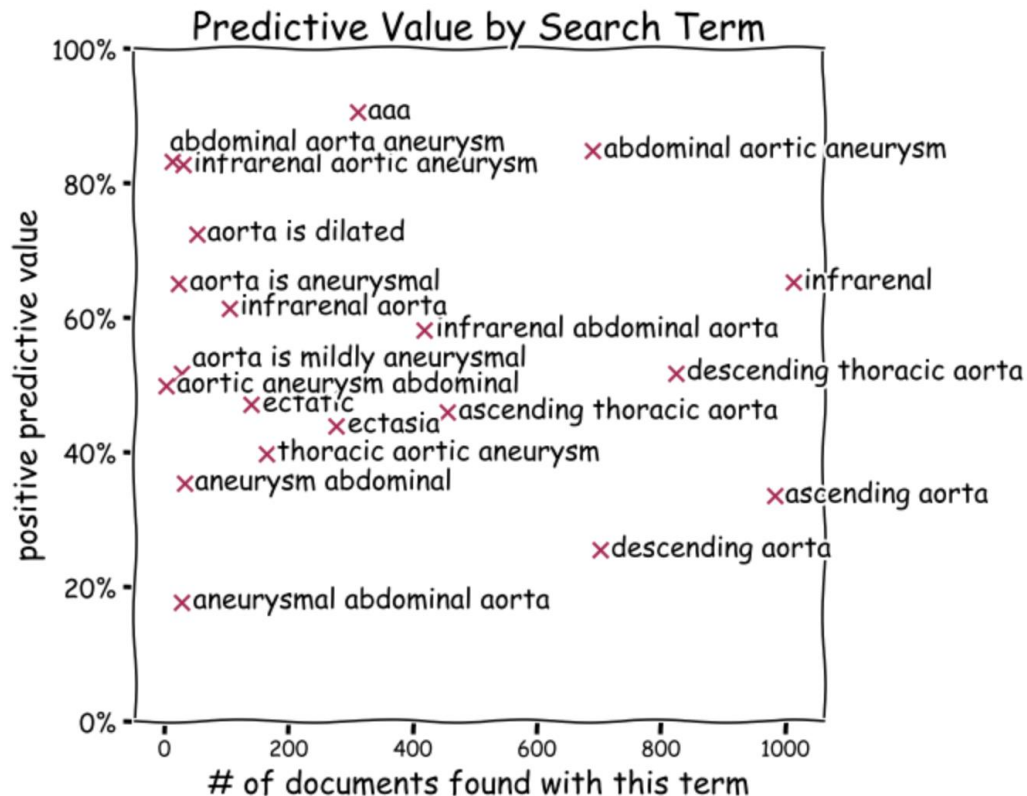
JSON file from Elasticsearch website downloaded and program written to automatically search entire database for results

Compared query results against ground truth dataset to find missing cases and reports reviewed for missed terms

# Using Kibana to visualize database



# Query Results



# Elasticsearch Results by Term

Number of patients	Terms Identified	Overall Sensitivity	Overall Specificity	Overall PPV	Overall NPV	TP	FP	TP/FP
18	infrarenal aortic aneurysm	0.05	1	0.88	0.87	14	2	7
102	aaa	0.31	0.99	0.84	0.9	84	16	5.25
36	aorta is dilated	0.1	0.99	0.75	0.88	27	9	3
201	abdominal aortic aneurysm	0.47	0.96	0.65	0.92	126	68	1.85
17	aorta is aneurysmal	0.04	1	0.65	0.87	11	6	1.83
5	abdominal aorta aneurysm	0.01	1	0.6	0.87	3	2	1.5
156	infrarenal abdominal aorta	0.31	0.96	0.55	0.9	84	70	1.2
61	infrarenal aorta	0.12	0.98	0.53	0.88	32	28	1.14
293	infrarenal	0.55	0.92	0.52	0.93	147	135	1.09
2	aortic aneurysm abdominal	0	1	0.5	0.87	1	1	1
15	aorta is mildly aneurysmal	0.03	1	0.47	0.87	7	8	0.88
84	ectatic	0.14	0.97	0.45	0.88	37	46	0.8
150	ectasia	0.23	0.95	0.41	0.89	61	86	0.71
265	ascending thoracic aorta	0.38	0.91	0.39	0.9	101	155	0.65
383	descending thoracic aorta	0.47	0.86	0.34	0.91	126	245	0.51
82	thoracic aortic aneurysm	0.1	0.97	0.33	0.87	26	52	0.5
20	aneurysm abdominal	0.02	0.99	0.3	0.87	6	14	0.43
424	ascending aorta	0.42	0.83	0.28	0.9	112	293	0.38
334	descending aorta	0.27	0.86	0.23	0.88	73	246	0.3
16	aneurysmal abdominal aorta	0.01	0.99	0.19	0.87	3	13	0.23
0	aneurysm abdominal aorta	0	0	0	0	0	0	0
0	aneurysm abdominal aortic	0	0	0	0	0	0	0
0	aorta abdominal aneurysm	0	0	0	0	0	0	0
888	all terms	0.92	0.65	0.29	0.98	247	597	0.41

# Abdominal Terms

Number of patients	Terms Identified	AAA Sensitivity	AAA Specificity	AAA PPV	AAA NPV
61	infrarenal aorta	0.147368421	0.982251803	0.466666667	0.916192447
293	<b>infrarenal</b>	<b>0.721052632</b>	0.91957848	0.485815603	<b>0.969023963</b>
156	infrarenal abdominal aorta	0.410526316	0.957848031	0.506493506	0.939097336
18	<b>infrarenal aortic aneurysm</b>	0.068421053	0.998336106	<b>0.8125</b>	0.91047041
102	aaa	0.405263158	0.987243483	0.77	0.940306392
201	abdominal aortic aneurysm	0.610526316	0.956738769	0.597938144	0.958866037
5	abdominal aorta aneurysm	0.015789474	0.998890738	0.6	0.905935614
0	aneurysm abdominal aorta	0			
20	aneurysm abdominal	0.010526316	0.990016639	0.1	0.904713634
0	aneurysm abdominal aortic	0			
16	aneurysmal abdominal aorta	0.015789474	0.992789795	0.1875	0.905412241
0	aorta abdominal aneurysm	0			
2	<b>aortic aneurysm abdominal</b>	0.005263158	<b>0.999445369</b>	0.5	0.905072828

# Thoracic Terms

Number of patients	Terms Identified	TAA Sensitivity	TAA Specificity	TAA PPV	TAA NPV
265	ascending thoracic aorta	0.621359223	0.898412698	0.25	0.977547496
383	<b>descending thoracic aorta</b>	<b>0.757281553</b>	0.844973545	0.210242588	<b>0.98458693</b>
82	thoracic aortic aneurysm	0.165048544	0.967724868	0.217948718	0.955091384
424	ascending aorta	0.631067961	0.82010582	0.160493827	0.976070529
334	descending aorta	0.378640777	0.851851852	0.122257053	0.96176822
36	<b>aorta is dilated</b>	0.203883495	0.992063492	<b>0.583333333</b>	0.958099131
15	aorta is mildly aneurysmal	0.029126214	0.993650794	0.2	0.949443883
17	<b>aorta is aneurysmal</b>	0.077669903	<b>0.995238095</b>	0.470588235	0.951923077

Number of patients	Terms Identified	Overall Sensitivity	Overall Specificity	Overall PPV	Overall NPV
84	<b>ectatic</b>	0.138059701	<b>0.973333333</b>	<b>0.445783133</b>	0.879057592
150	<b>ectasia</b>	<b>0.22761194</b>	0.950144928	0.414965986	<b>0.887865655</b>

# Performance with NegEx

Terms Identified	Overall PPV	PPV with NegEx	Overall TP	TP with NegEx	Overall FP	FP with NegEx	TP/FP	TP/FP with NegEx
infrarenal aortic aneurysm	0.88	0.88	14	14	2	2	7	7
aaa	0.84	0.86	84	82	16	13	5.25	6.31
aorta is dilated	0.75	0.75	27	27	9	9	3	3
abdominal aortic aneurysm	0.65	0.84	126	116	68	22	1.85	5.27
aorta is aneurysmal	0.65	0.65	11	11	6	6	1.83	1.83
abdominal aorta aneurysm	0.6	0.6	3	3	2	2	1.5	1.5
infrarenal abdominal aorta	0.55	0.55	84	84	70	70	1.2	1.2
infrarenal aorta	0.53	0.53	32	32	28	28	1.14	1.14
infrarenal	0.52	0.52	147	146	135	135	1.09	1.08
aortic aneurysm abdominal	0.5	0.5	1	1	1	1	1	1
aorta is mildly aneurysmal	0.47	0.47	7	7	8	8	0.88	0.88
ectatic	0.45	0.46	37	37	46	44	0.8	0.84
ectasia	0.41	0.43	61	60	86	79	0.71	0.76
ascending thoracic aorta	0.39	0.41	101	98	155	139	0.65	0.71
descending thoracic aorta	0.34	0.34	126	126	245	242	0.51	0.52
thoracic aortic aneurysm	0.33	0.87	26	20	52	3	0.5	6.67
aneurysm abdominal	0.3	0.3	6	6	14	14	0.43	0.43
all terms	0.29	0.3	247	247	597	563	0.41	0.44
ascending aorta	0.28	0.28	112	110	293	288	0.38	0.38
descending aorta	0.23	0.23	73	73	246	243	0.3	0.3
aneurysmal abdominal aorta	0.19	0.19	3	3	13	13	0.23	0.23

# Generated Output to Clinical Team – Version 1

A	B	C	D
mrn	terms_found	DOB	Age
	ascending aorta, descending aorta		
	descending thoracic aorta, ascending aorta; descending thoracic aorta, ascending		
	descending thoracic aorta. ascending aorta		

E	F	G	H	I	J	K
Smoking Hx	Hypertension	prev. review	accession_numbers	Review Y/N	Reviewer's notes	document link
Former Smoker	Yes					<a href="#">doc 1</a>
Former Smoker						<a href="#">doc 1</a>
Former Smoker						<a href="#">doc 1</a>

## FINDINGS:

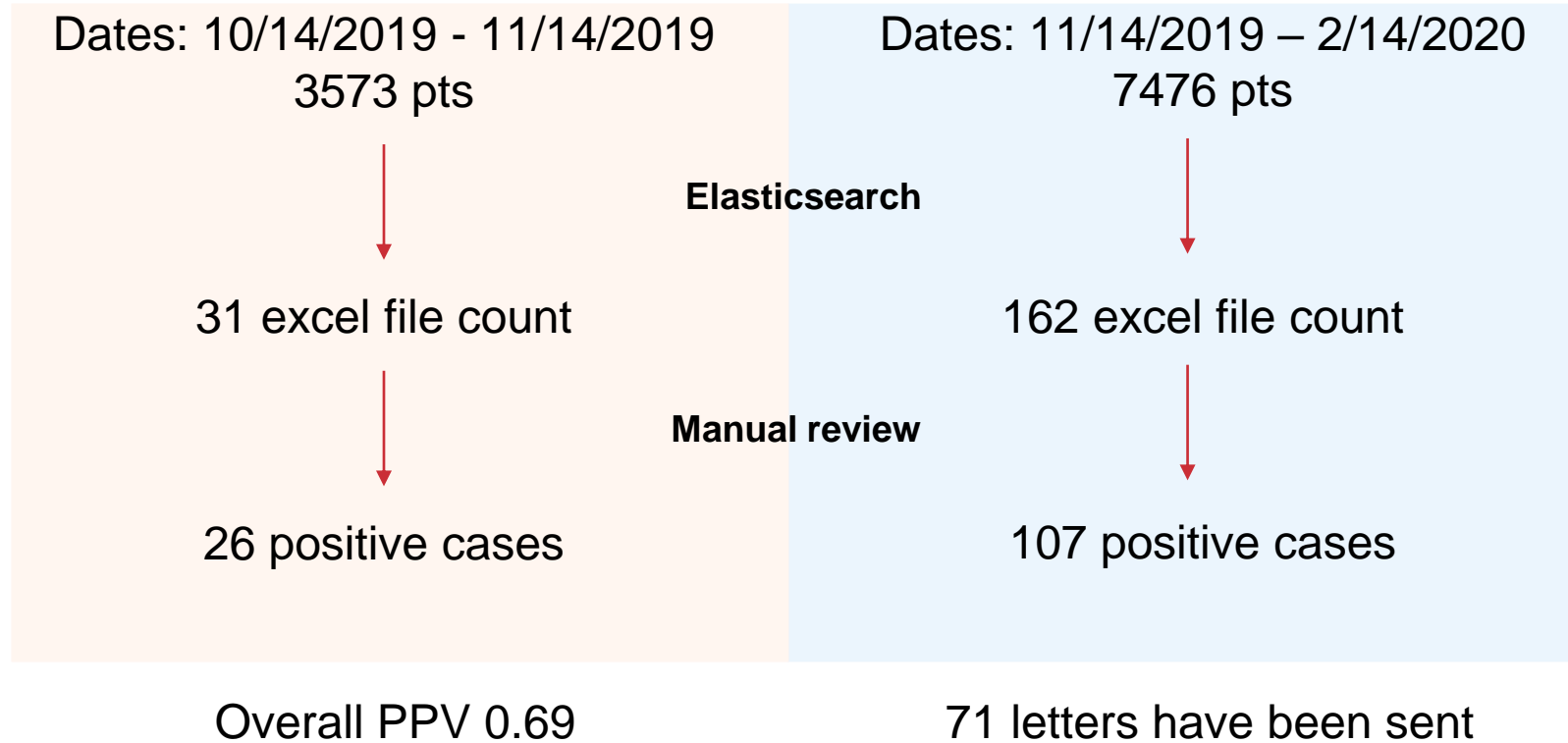
**VESSELS:** Interval increase in size of an **abdominal aortic aneurysm** which now measures approximately 5.2 x 5.2 x 9.0 cm (AP by TV by CC),

## Generated Output to Clinical Team – Version 2

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Pt. name	mrn	terms	HTN	prev. rev.	acc. #s			Measure ment	Measure ment	Measure ment	Measure ment Iliac			Other aneur./st		
						Thoracic Aorta A	Abdomin al Aorta	Ascendin g Aorta	Descendi ng Aorta	Abdomin al Aorta	(cm)	ectasia	dissect	enosis	Endolea	Repair

R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Repair Date	Case of progression	Notified pt/ PMC	New/ Incident	Vasc. consult	Vasc. surgeon	CT	PMD	Had aneurysm follow-up appointment?	Internal/ Ext.	Loss to Follow-	Requires provider letter	document links

# Identified Cases Undergo Clinical Review



# Practical Application of this Session

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This project would not be possible without a supportive and involved clinical team

Having a manually-curated ground truth dataset was instrumental in starting the project

Creating a simpler process is a consideration when implemented more easily than an advanced model

# Future Work

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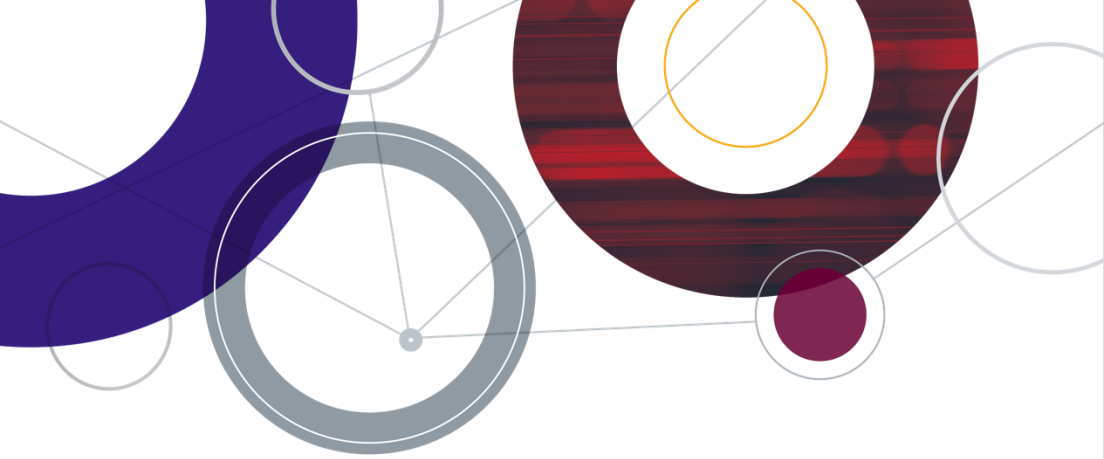
Improving query with updated terms and CPT codes

Exploring use of NLP to identify smoking history

Analyzing the radiographic image data to predict increased risk of rupture

Predicting which patients should be screened for aortic aneurysms

Creating a relational database of patients for our Aortic Center for better patient tracking




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**#WhyInformatics**

# Thank you!

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