The Green Button Project

Physician Symposium Session #3, February 11 2019

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Conflict of interest

Alison Callahan, PhD, has no real or apparent conflicts of interest to report.

Agenda

- The Green Button origin story
- Anatomy of the consult service
- Methods and challenges
- Learning from the first 100 consults
- Deploying the service at a new site
- Ongoing efforts

Learning objectives

- Define use cases for an informatics consult service
- Describe requirements for setting up an informatics consult service
- Plan deployment of an informatics consult service at a new site

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Acknowledgements

Informatics Consult team


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Meet Laura

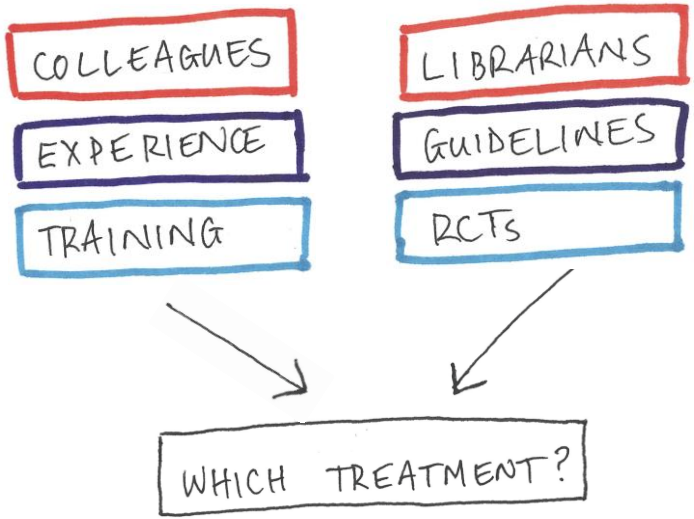
Source: Mayo Foundation for Medical Education and Research

A teenager with systemic lupus erythematosus

- proteinuria
- antiphospholipid antibodies
- pancreatitis

Managing Laura's care

Source: Mayo Foundation for Medical Education and Research



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The Origin of the Green Button

Evidence-Based Medicine in the EMR Era

Jennifer Frankovich, M.D., Christopher A. Longhurst, M.D., and Scott M. Sutherland, M.D.

Results of Electronic Search of Patient Medical Records (for a Cohort of 98 Pediatric Patients with Lupus) Focused on Risk Factors for Thrombosis Relevant to Our 13-Year-Old Patient with Systemic Lupus Erythematosus.*

Outcome or Risk Factor	Keywords Used to Conduct Expedited Electronic Search	Prevalence of Thrombosis	Relative Risk (95% CI)
		no./total no (%)	
Outcome — thrombosis	"Thrombus," "Thrombosis," "Blood clot"	10/98 (10)	Not applicable
Thrombosis risk factor			
Heavy proteinuria (>2.5 g per deciliter)			
Present at any time	"Nephrosis," "Nephrotic," "Proteinuria"	8/36 (22)	7.8 (1.7–50)
Present >60 days	"Urine protein"	7/23 (30)	14.7 (3.3–96)
Pancreatitis	"Pancreatitis," "Lipase"	5/8 (63)	11.8 (3.8–27)
Antiphospholipid antibodies	"Aspirin"	6/51 (12)	1.0 (0.3–3.7)

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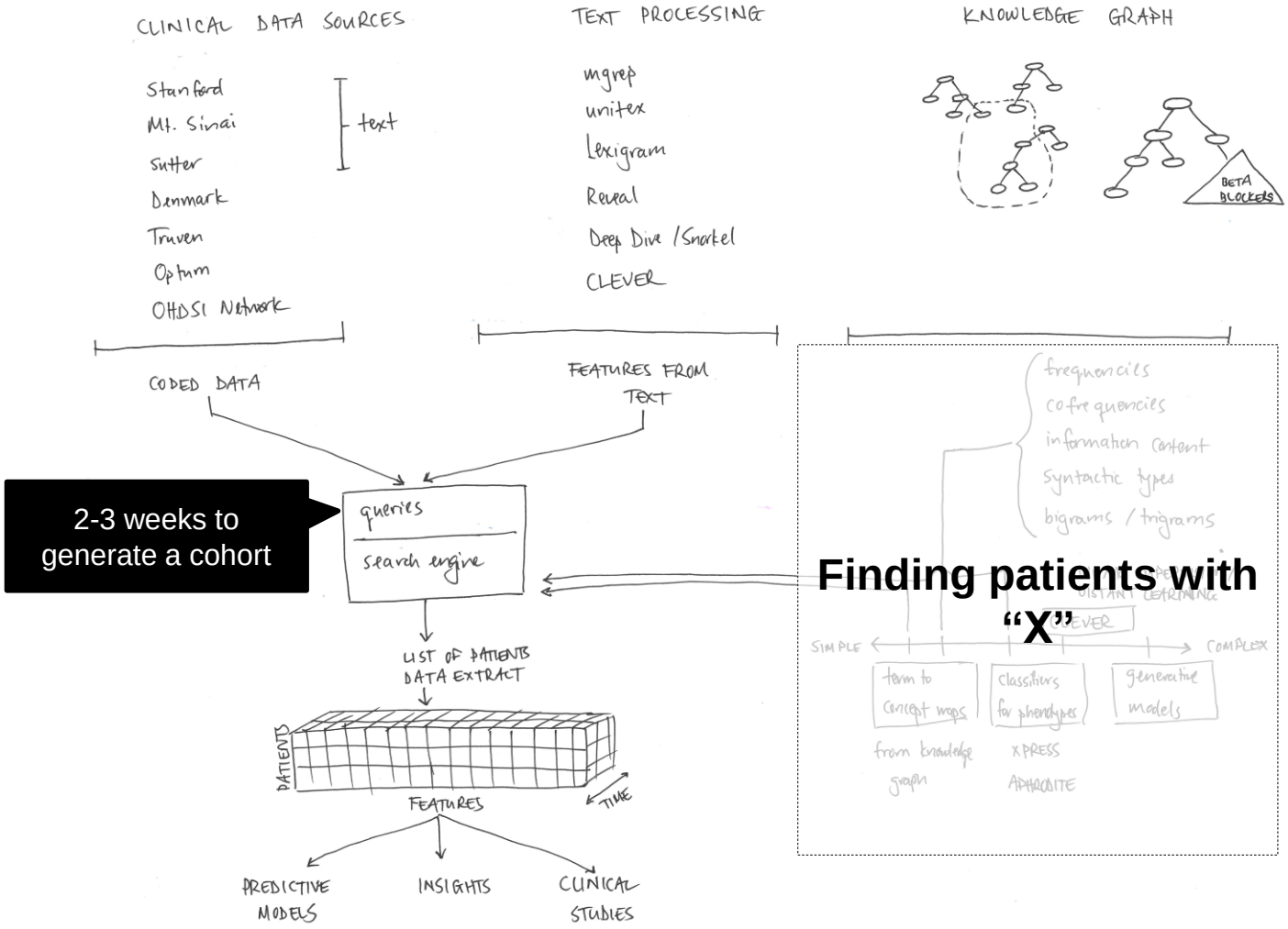

2-3 weeks to generate a cohort

Finding patients with "X"

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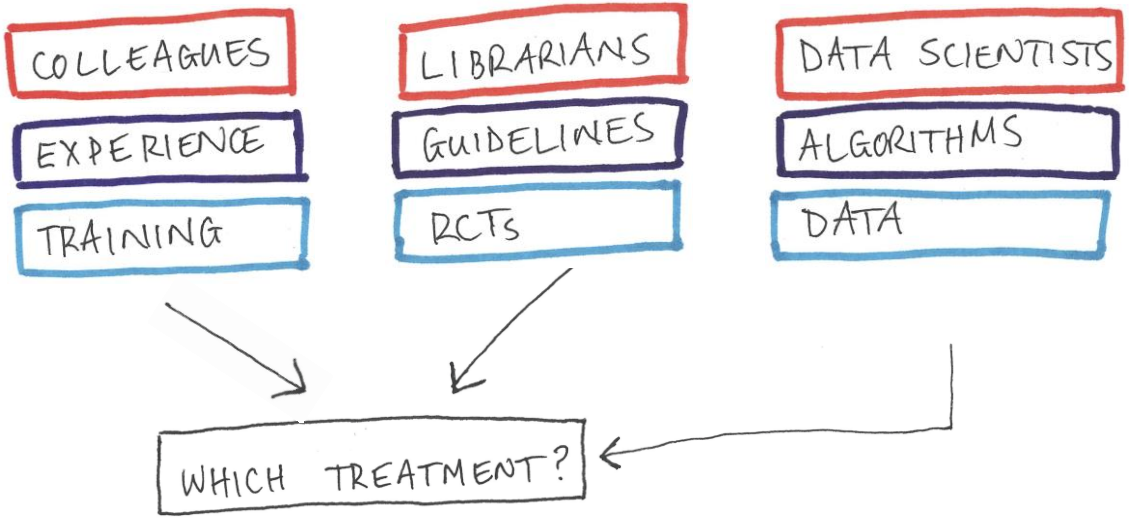
PATIENTS & RESEARCH

By Christopher A. Longhurst, Robert A. Harrington, and Nigam H. Shah

A 'Green Button' For Using Aggregate Patient Data At The Point Of Care

DOI: 10.1377/hlthaff.2014.0099
HEALTH AFFAIRS 33,
NO. 7 (2014): 1229–1235



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The Informatics Consult Service

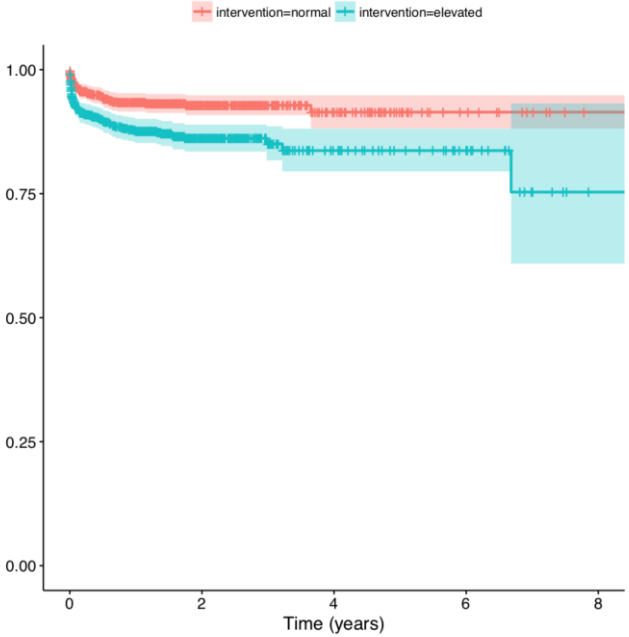
Given a specific case, provide a report with a descriptive summary of similar patients in Stanford's clinical data warehouse, the common treatment choices made, and the observed outcomes after specific treatment choices.

An institutional review board approved study (IRB # 39709) over one year.

http://greenbutton.stanford.edu

An example report

Mildly elevated serum free light chains and subsequent malignancy



	N	Observed	Expected	$(O-E)^2/E$	$(O-E)^2/V$	chisq	pvalue
normal	760	49	73.365	8.092	16.413	16.4	5.09e-05
elevated	760	96	71.635	8.287	16.413	16.4	5.09e-05

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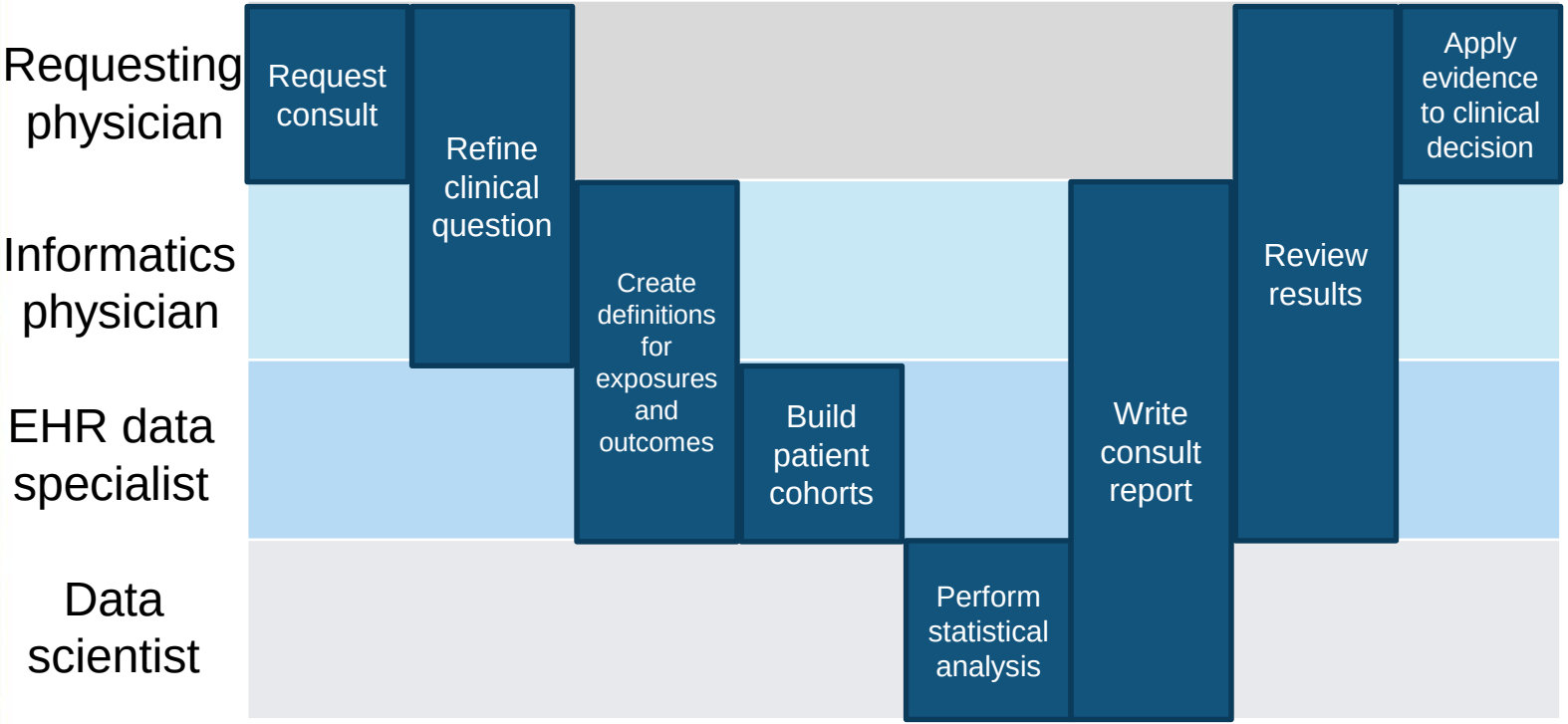
The process

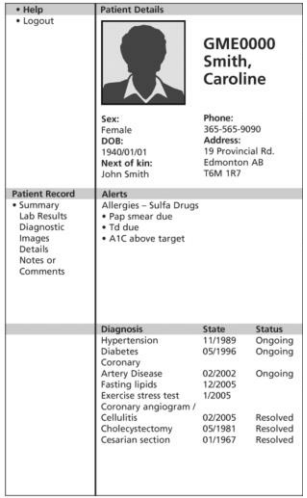


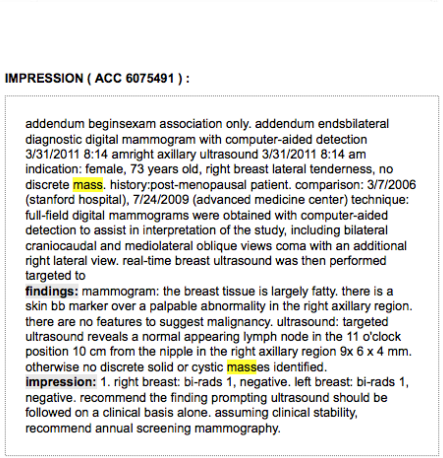
24 to 72 hours

Methods and challenges

- Building patient cohorts accurately and quickly
- Asking the right question
- Controlling for confounding
- Ensuring quick turnaround

Building patient cohorts



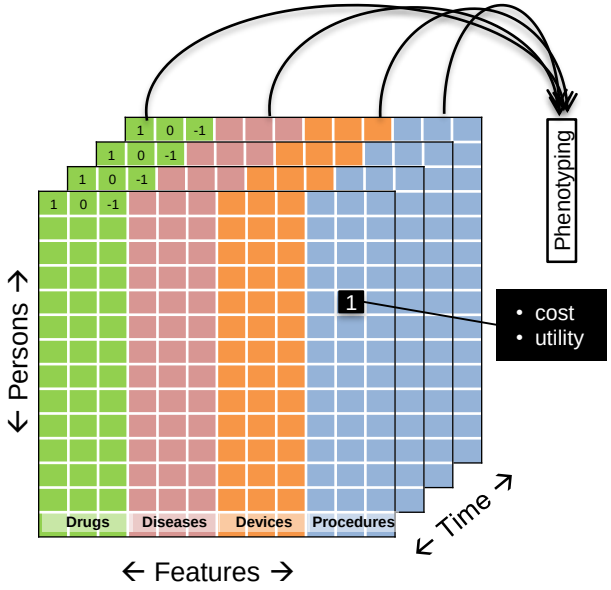


IMPRESSION (ACC 6075491) :

addendum beginsexam association only. addendum endsbilateral diagnostic digital mammogram with computer-aided detection 3/31/2011 8:14 amright axillary ultrasound 3/31/2011 8:14 am indication: female, 73 years old, right breast lateral tenderness, no discrete mass. history:post-menopausal patient. comparison: 3/7/2006 (stanford hospital), 7/24/2009 (advanced medicine center) technique: full-field digital mammograms were obtained with computer-aided detection to assist in interpretation of the study, including bilateral craniocaudal and mediolateral oblique views coma with an additional right lateral view. real-time breast ultrasound was then performed targeted to

findings: mammogram: the breast tissue is largely fatty. there is a skin bb marker over a palpable abnormality in the right axillary region. there are no features to suggest malignancy. ultrasound: targeted ultrasound reveals a normal appearing lymph node in the 11 o'clock position 10 cm from the nipple in the right axillary region 9x 6 x 4 mm. otherwise no discrete solid or cystic masses identified.

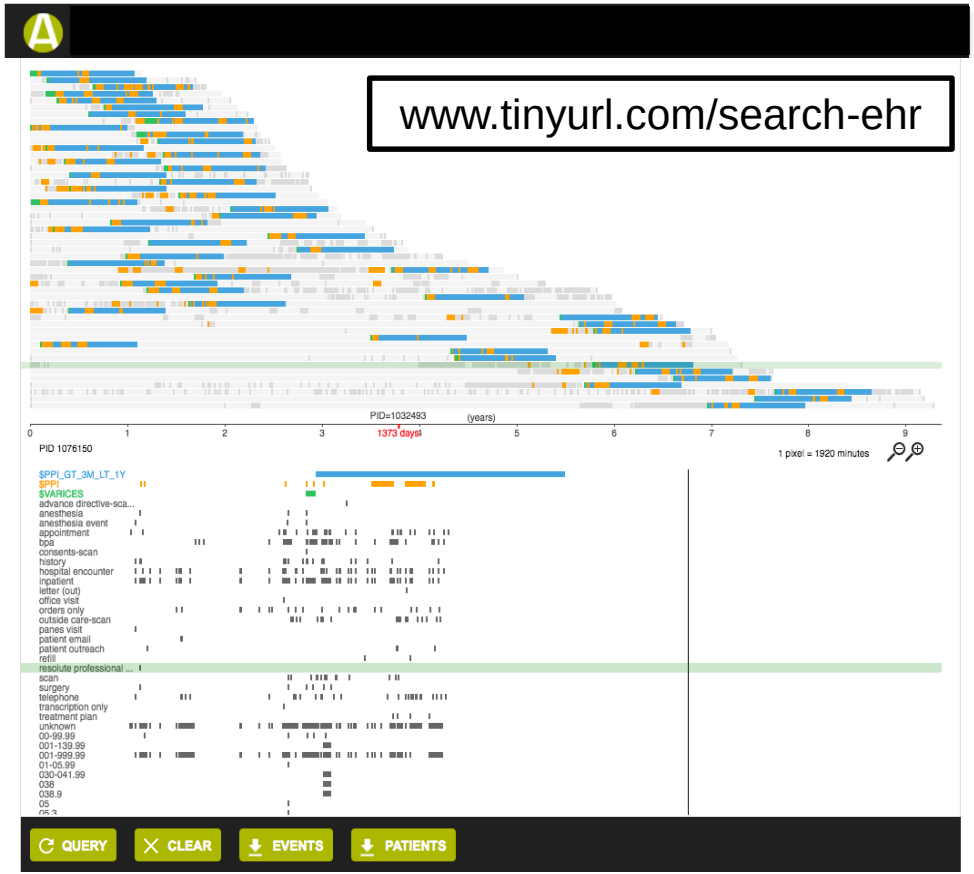
impression: 1. right breast: bi-rads 1, negative. left breast: bi-rads 1, negative. recommend the finding prompting ultrasound should be followed on a clinical basis alone. assuming clinical stability, recommend annual screening mammography.



From timelines to data frames

1. How will you handle time?
2. What features will you use?
3. How will you state your phenotype definition?

The search engine



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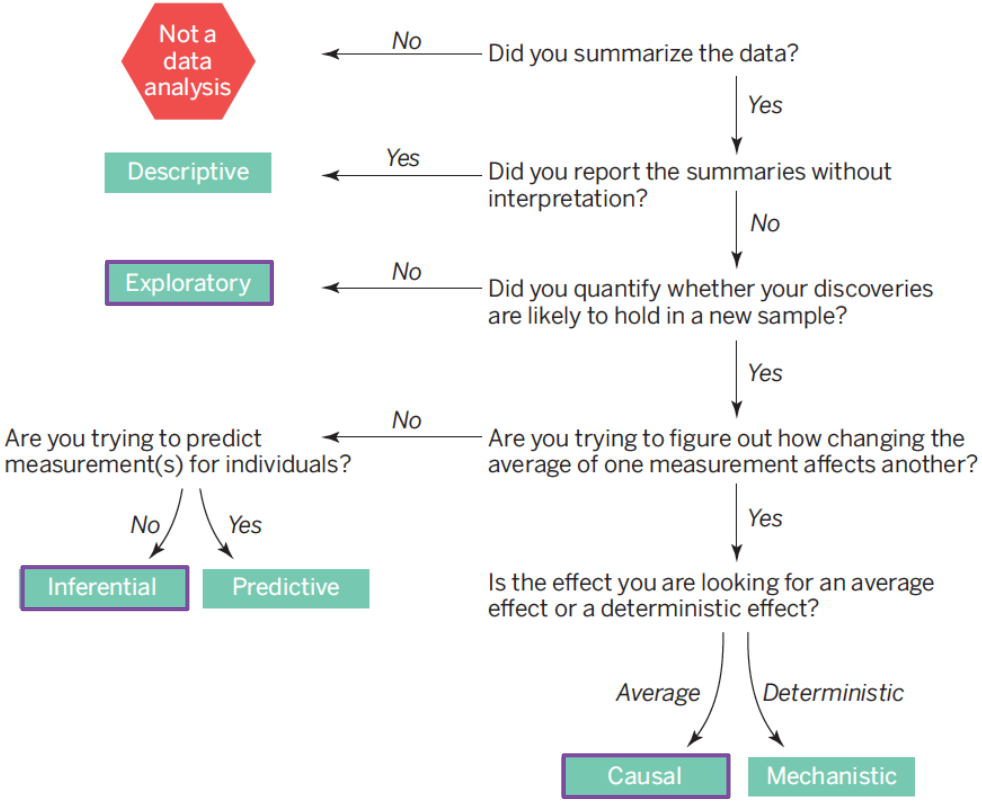
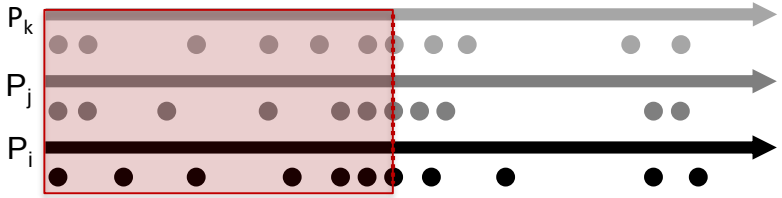
Asking the right question



Controlling for confounding

- Identify subsets of patient cohorts that are “similar”
  - Matching on age, gender, record length, year
  - Using propensity score matching



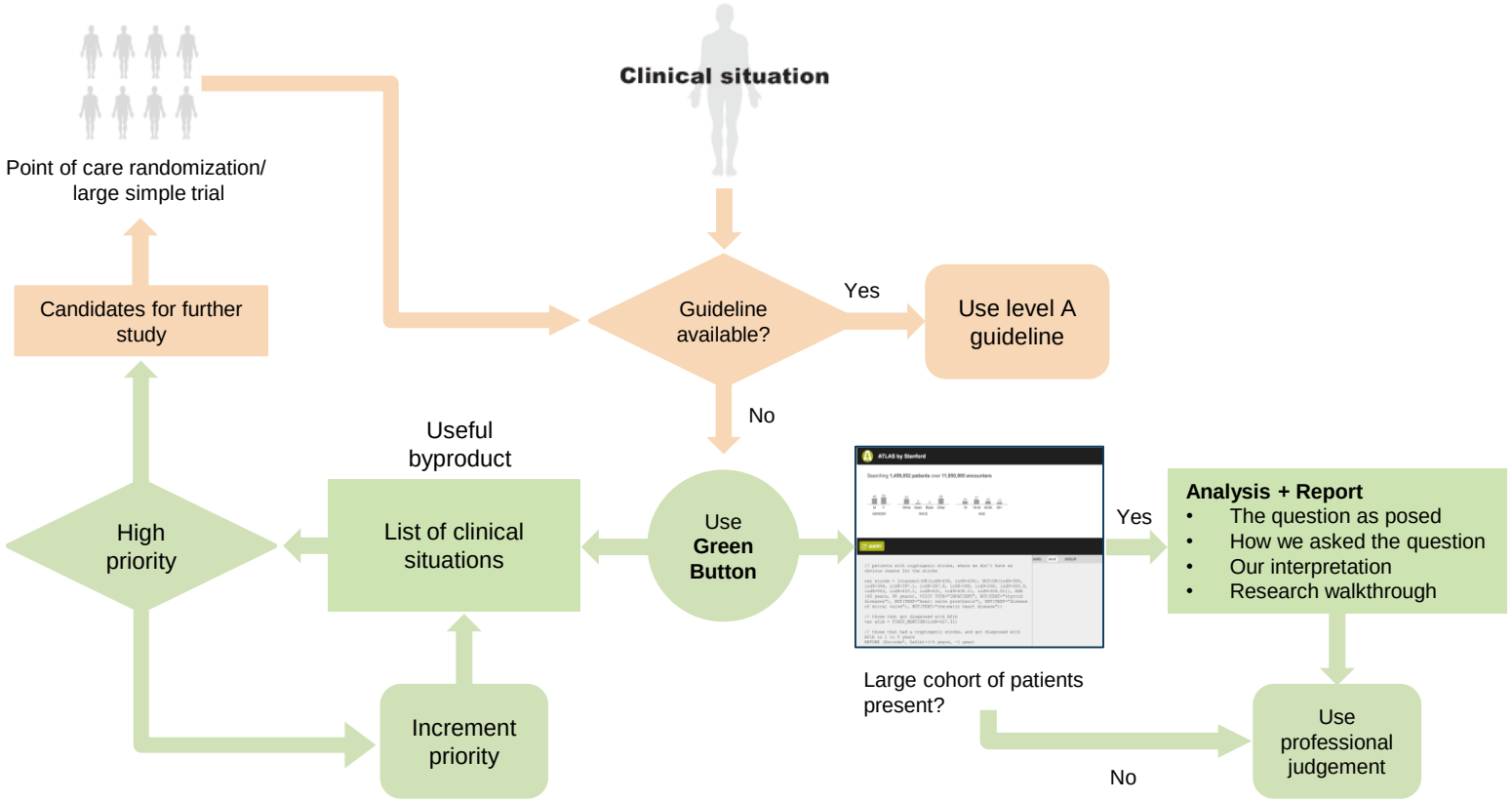
What we do to not be wrong

- Use negative controls for empirical calibration
- E-values to quantify the degree of confounding that can produce the observed effect
- Ask the question using multiple datasets
- Schedule an in-person debrief

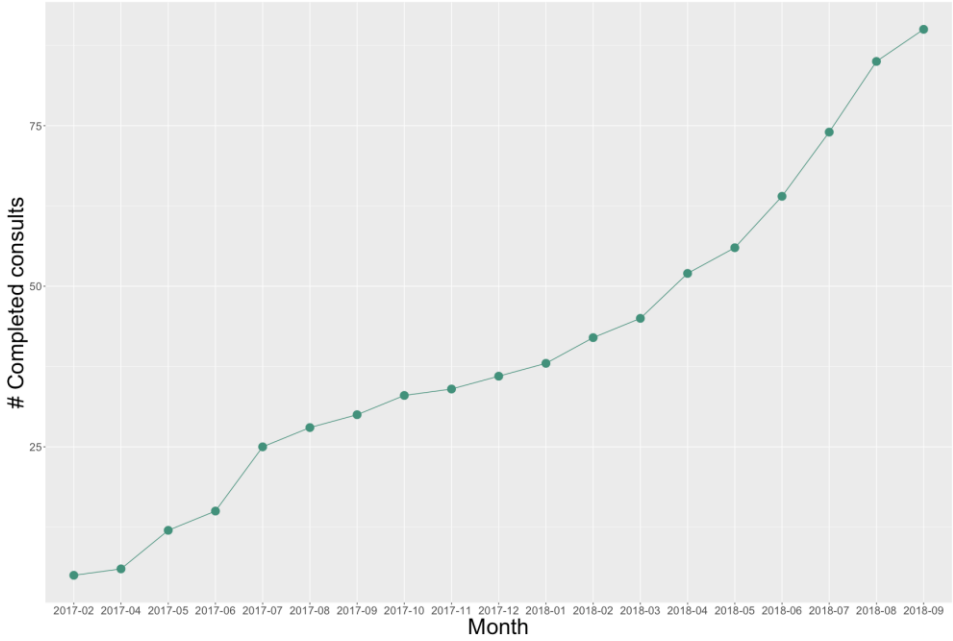
Ensuring quick turnaround

- Search engine API available in CRAN
- R library for data pre-processing
- Semi-automated pipeline for survival and causal analyses, report generation

```r
pull_events <- function(input_file) {
  data <- read.csv(input_file, header=TRUE, sep='\t', stringsAsFactors = FALSE)
  data <- data[c(1, 2, 3, 7, 8)]
  colnames(data) <- c("patient_id", "event", "event_year", "event_start", "event_end")
  return(data)
}

pull_index <- function(input_file) {
  data <- read.csv(input_file, header=TRUE, sep='\t')
  data <- data[c(1, 2, 3, 7)]
  colnames(data) <- c("patient_id", "intervention", "index_year", "index_start")
  return(data)
}

build_summary_plots <- function(..., legend=FALSE){
  datasets <- list(...)

  for (i in 1:length(datasets)){
    datasets[[i]] <- cbind(datasets[[i]], group=rep(LETTERS[i], nrow(datasets[[i]]) ) )
  }

  data <- do.call("rbind", datasets)
  data$race <- ifelse(is.na(data$race), "UNKNOWN", data$race)
  data$race <- factor(toupper(data$race), levels=c("ASIAN", "BLACK", "WHITE", "OTHER", "UNKNOWN"))
  data$gender <- factor(toupper(data$gender), levels=c("FEMALE", "MALE"))
  data$num_encounters <- ifelse(is.na(data$num_encounters), 0, data$num_encounters)
  data$encounter_category <- ifelse(data$num_encounters == 0, "0-10", data$encounter_category)

  encounter_data_summarised <- data %>% group_by(group,encounter_category) %>% summarise (n = n()) %>% mutate(pct = (n / sum(n))*100)

  age_data_summarised <- data %>% group_by(group,age_category) %>% summarise (n = n()) %>% mutate(pct = (n / sum(n))*100)
```



Learning from the first 100 consults



- How many? 55%
- Which treatment? 30%
- How long? 15%

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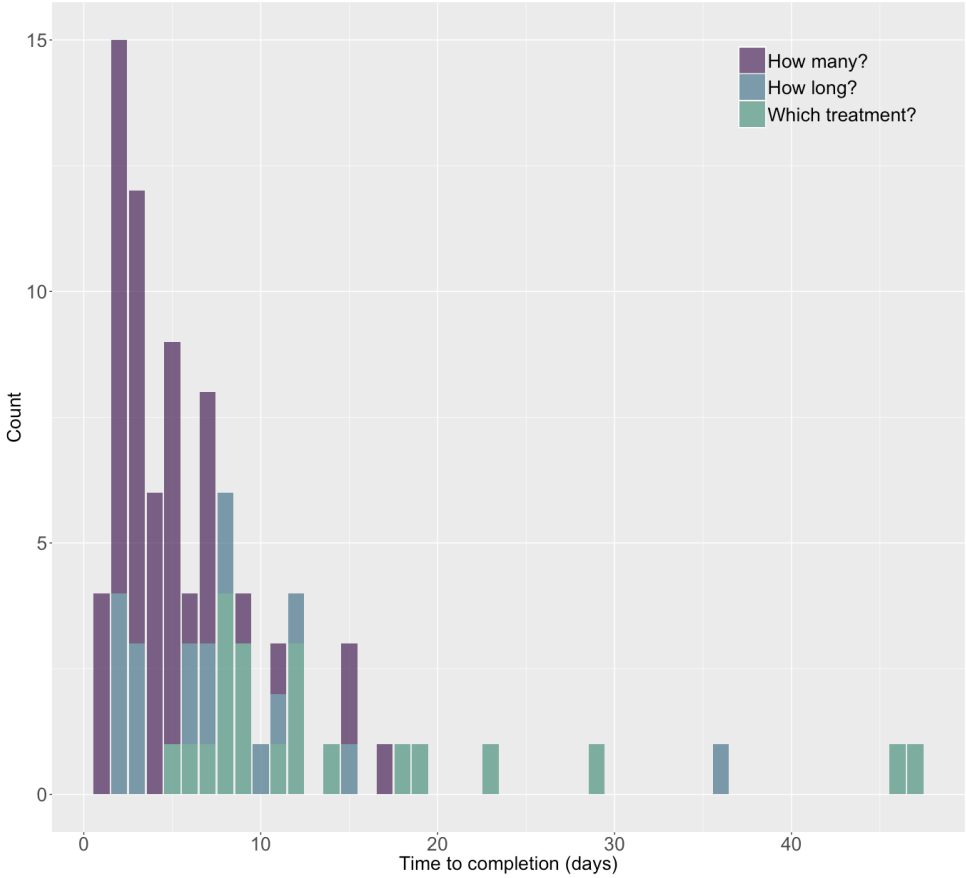
Learning from the first 100 consults



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Learning from the first 100 consults

- **How we asked the question**

- How likely would you be to use this service again?
- How likely would you be to refer a colleague to use this service?
- How would you describe this report to a colleague if they asked you what you received as an answer to your question?
- Is there anything about the report that you think a colleague might find unclear or unnecessary?
- If you had to use 3 words to describe the report as you saw it today, what would those be?

Would you add or remove anything from this section?

On a scale of 1 to 5 with 5 being extremely helpful and 1 being not at all helpful, how helpful is this area?

"likely to recommend" was 100%

Deploying the service at your site

- Institutional support
- Data science expertise
- Marketing
- A process to sanity-check the data and consult findings

THE STANFORD INFORMATICS CONSULT SERVICE HANDBOOK

A guide to provide informatics consults as a clinical and research service

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We're not the first to provide an on-demand informatics consult service

Estimating Prognosis with the Aid of a Conversational-Mode Computer Program

ALVAN R. FEINSTEIN, M.D., JOEL F. RUBINSTEIN, M.D., and WALTER A. RAMSHAW, M.A.,

THE CURRENT LIBRARY CONTAINS 678 PATIENTS.
.....

LISTING OF CHART NO. 1

VARIABLE	CURRENT PT.'S VALUE	NO. OF BASE POPULATION WITH SAME VALUE	NO. AND PERCENT OF 6 MONTH SURVIVORS
AGE	65	33	12 (36%)
SEX	MALE	602	246 (41%)
SMOKING	CIGARTTS	608	251 (41%)
CLINSTGE	SYSTEMIC	222	94 (42%)
ANATSTGE	MEDIANOD	164	81 (49%)
LATERALZTN	PRESENT	658	277 (42%)
MICROTYPE	HISTOLGY	275	81 (29%)
COMORBIDITY	NONE	506	235 (46%)
CHRCOUGH	PRESENT	266	115 (43%)
ACTIVETB	ABSENT	660	271 (41%)
BLOODYPLFLD	ABSENT	637	273 (43%)
BRONCHOMASS	PRESENT	142	61 (43%)
CONTRASURG	ABSENT	308	182 (59%)
PRETHERINT	4.0	14	2 (14%)

...PAUSE FOR MORE CALCULATIONS...
THE FOLLOWING CALCULATIONS OMIT ASYMPTOMATIC PATIENTS FOR WHOM PRETHERINT IS NOT DEFINED

.....

THE NUMBER OF PEOPLE BELONGING TO THE SUBSET OF PEOPLE DEFINED BY CHART NO. 13 IS 6.
6 MONTH SURVIVAL RATE EQUALS 67%(4).

ENTER 1 IF YOU WISH TO AMEND A CHART FURTHER
ENTER 0 IF YOU WISH TO OBTAIN SURVIVAL RATES
>0
ENTER THE NUMBER OF THE CHART ON WHICH YOU WISH TO BASE YOUR ESTIMATION
>13

...PAUSE TO COMPUTE SURVIVAL RATES...
.....

ESTIMATION BASED ON CHART NO. 13

TREATMENT GROUPS	TOTAL	* * * * PERCENTAGE ALIVE AFTER * * * * 3 MON	6 MON	1 YEAR	3 YEAR	5 YEAR	POST OP DEATH RATE
ALL	6	67%	67%	67%	50%	33%	0%
SURGERY	5	80%	80%	80%	60%	40%	0%
-ALONE	3	100%	100%	100%	67%	33%	0%
-THEN XRAY	2	50%	50%	50%	50%	50%	0%
XRAY	3	33%	33%	33%	33%	33%	0%
-ALONE	1	0%	0%	0%	0%	0%	0%

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PROGNOSTIGRAM CIS - 79
FOR INDEX CASE : PATIENT A

WITH THE FOLLOWING CRITERIA :
HISTORY OF MYOCARDIAL INFARCTION
NO HISTORY OF RECURRENT CHEST PAIN
NO HISTORY OF CONGESTIVE HEART FAILURE
HEART SIZE NORMAL BY CHEST X-RAY
A SUBGROUP OF 18 PATIENTS WAS FOUND.

ASSOCIATED CLINICAL FINDINGS IN THIS SUBGROUP

MALES (% OF PATIENTS)	=	100.0%
AGE (% OF PATIENTS WITHIN 5 YRS.)	=	33.3%
DURATION OF IHD (% OF PATIENTS WITHIN 12 MONTHS)	=	5.6%
TYPICAL ANGINA (% OF PATIENTS)	=	.0%
CHEST PAIN STABLE (% OF PATIENTS)	=	.0%
NYHA FUNCTIONAL CLASS FOR ANGINA = 4 (% OF PATIENTS)	=	.0%
HISTORY OF MYOCARDIAL INFARCTION (% OF PATIENTS)	=	100.0%
NO HISTORY OF CONGESTIVE HEART FAILURE (% OF PATIENTS)	=	100.0%
NO HISTORY OF HYPERTENSION (% OF PATIENTS)	=	72.2%
NO HISTORY OF DIABETES MELLITUS (% OF PATIENTS)	=	94.4%
HISTORY OF SMOKING (% OF PATIENTS)	=	64.7%
NO PRIOR TREATMENT WITH B-BLOCKERS (% OF PATIENTS)	=	88.9%
NO VENTRICULAR GALLOP (% OF PATIENTS)	=	100.0%
NO PERIPHERAL BRUITS (% OF PATIENTS)	=	100.0%
SERUM CHOLESTEROL (MEAN +/- SD)	=	233.7+/- 53.2
HEART SIZE NORMAL, CHEST X-RAY (% OF PATIENTS)	=	100.0%
NO DIAGNOSTIC Q-WAVES, ECG (% OF PATIENTS)	=	43.8%
NO CONDUCTION ABNORMALITIES (% OF PATIENTS)	=	87.5%
NO RESTING ST-T WAVE CHANGES (% OF PATIENTS)	=	75.0%
EXERCISE TEST POSITIVE (% OF PATIENTS)	=	18.2%
LEFT VENTRICULAR END-DIASTOLIC PRESSURE (MEAN +/- SD)	=	10.6+/- 3.8
ARTERIOVENOUS OXYGEN DIFFERENCE (MEAN +/- SD)	=	4.8+/- 1.0
CARDIAC INDEX IN ML/MIN/SQ M. (MEAN +/- SD)	=	2931.0+/-615.3
EJECTION FRACTION (MEAN +/- SD)	=	45.5+/- 9.3
NO SIGNIFICANT CORONARY DIEASE (% OF PATIENTS)	=	5.6%
NORMAL LEFT VENTRICULAR CONTRACTION (% OF PATIENTS)	=	27.8%
NO LEFT VENTRICULAR ANEURYSMS (% OF PATIENTS)	=	94.4%
NO MITRAL INSUFFICIENCY (% OF PATIENTS)	=	100.0%

PROGNOSTIC TABULATION

	MEDICINE				SURGERY			
	ALIVE	DEAD	NRA*	SURVIVAL	ALIVE	DEAD	NRA*	SURVIVAL
SURGICAL					2	0	0	100.0%
SIX-MONTH	16	0	0	100.0%	2	0	0	100.0%
ONE-YEAR	10	0	6	100.0%	2	0	0	100.0%
TWO-YEAR	6	0	4	100.0%	2	0	0	100.0%
THREE YEAR	1	0	5	100.0%	2	0	0	100.0%

*NRA=NOT YET REACHED ANNIVERSARY

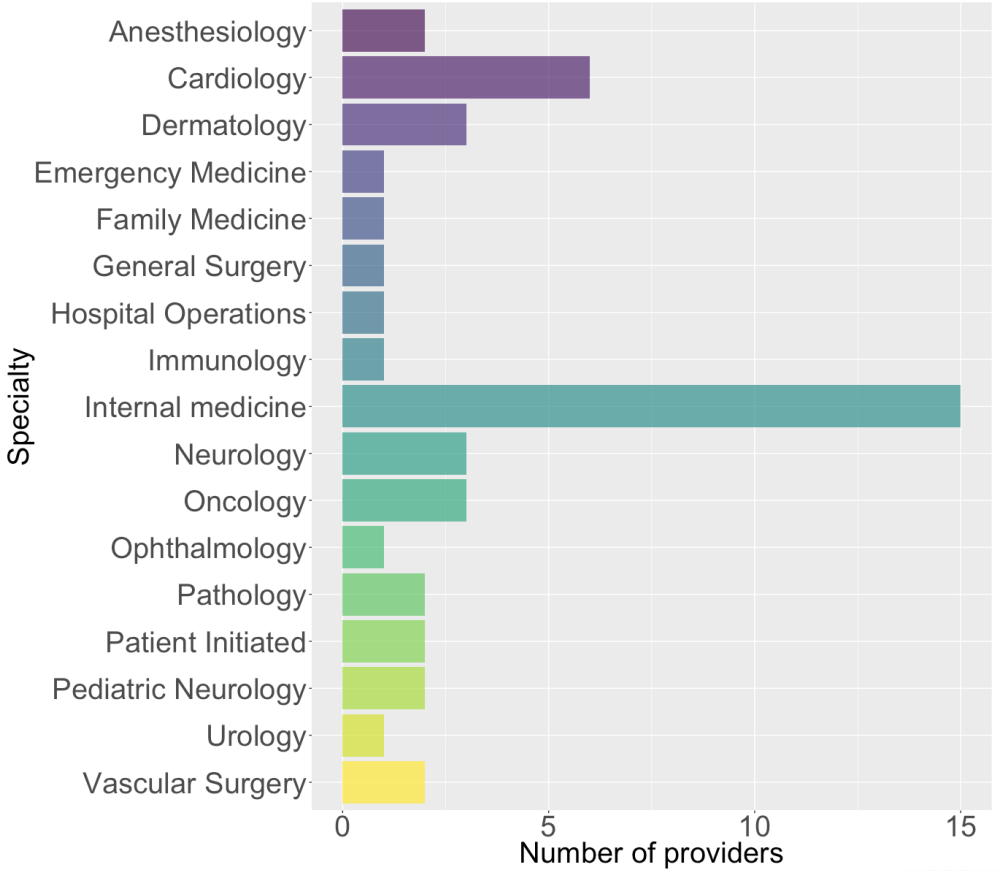
THERE WERE 0 PERIOPERATIVE MYOCARDIAL INFARCTIONS. SUBSEQUENTLY 0 SURGICALLY TREATED PATIENTS HAVE HAD INFARCTIONS. 0 MEDICALLY TREATED PATIENTS HAVE HAD INFARCTIONS.

AT THE TWO-YEAR FOLLOW-UP 3 OUT OF 5 MEDICALLY TREATED PATIENTS WERE PAIN-FREE AND 2 OUT OF 2 SURGICALLY TREATED PATIENTS WERE PAIN-FREE.

Fig 3.—Prognostic report of patient A.

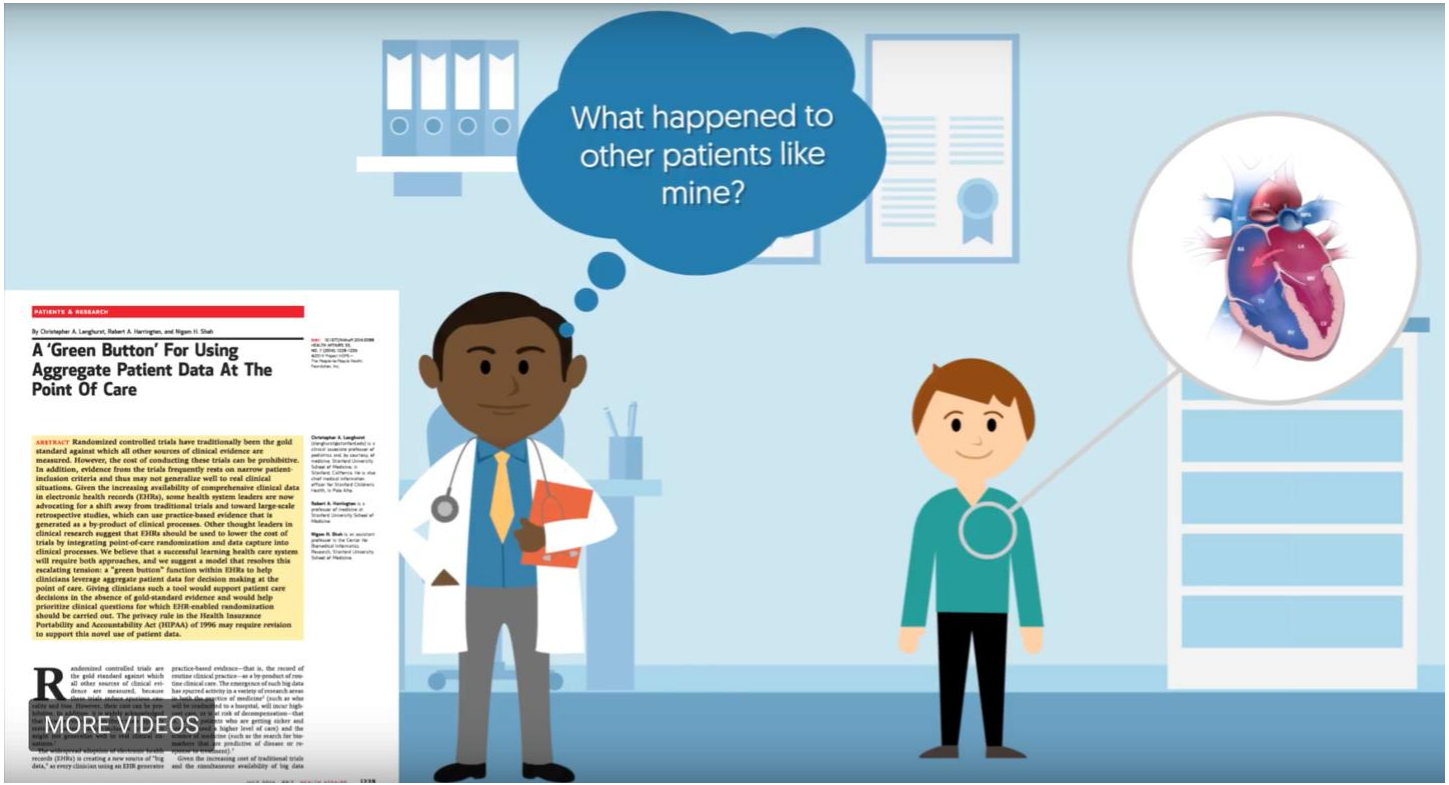
Now versus then

Stanford: 3 million
Optum: 55 million
Truven: 126 million



Open questions and ongoing efforts

- **What is really useful?**
  - Description of what happened
  - Estimation: Population or Individual level
  - Patient level prediction
- **Financial viability – who can pay for this "test"?**
- **Informatics research**
  - Phenotyping (how do I know the patient had X)
  - Representation learning
  - Matching, and population level inference
  - Personalized effect estimates
- **Deploying as a hospital-side service at Stanford Health Care**



http://greenbutton.stanford.edu

Thank you! Questions?

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@clssfr

Please complete the online session evaluation!

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