25 min

Interoperability and Clinical Repositories:

UC-REX -- Federated Querying of Multi-Site Clinical Data

Michael Hogarth, MD

Professor of Medicine, UC Davis

http://www.hogarth.org

What I am talking about today

- Where are we today with HIT?

- Inevitability of HIE's

- "Secondary use" of clinical data

- **Clinical Data "repository" Interoperability....**

- Federated querying of clinical data from 5 Univ. of California academic medical centers
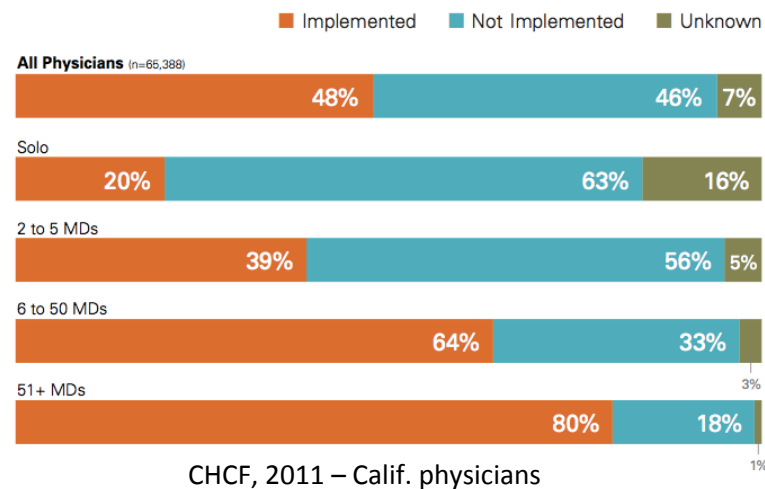
HIT Adoption: US and California

Adoption of EMR/EHR systems by office-based physicians has increased.

Figure 1. Percentage of office-based physicians with EMR/EHR systems: United States, 2001–2009, and preliminary 2010–2011
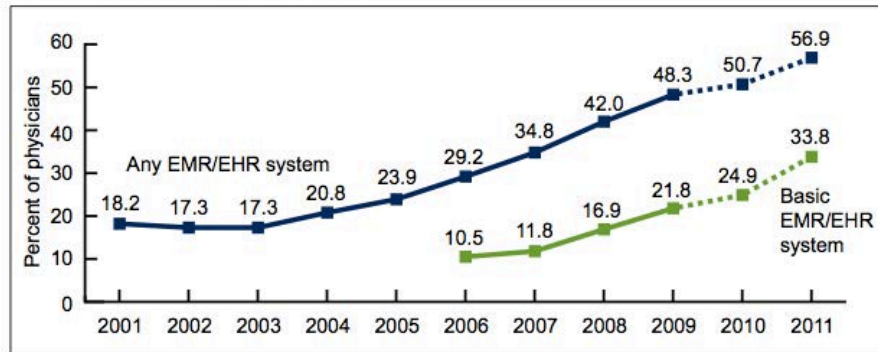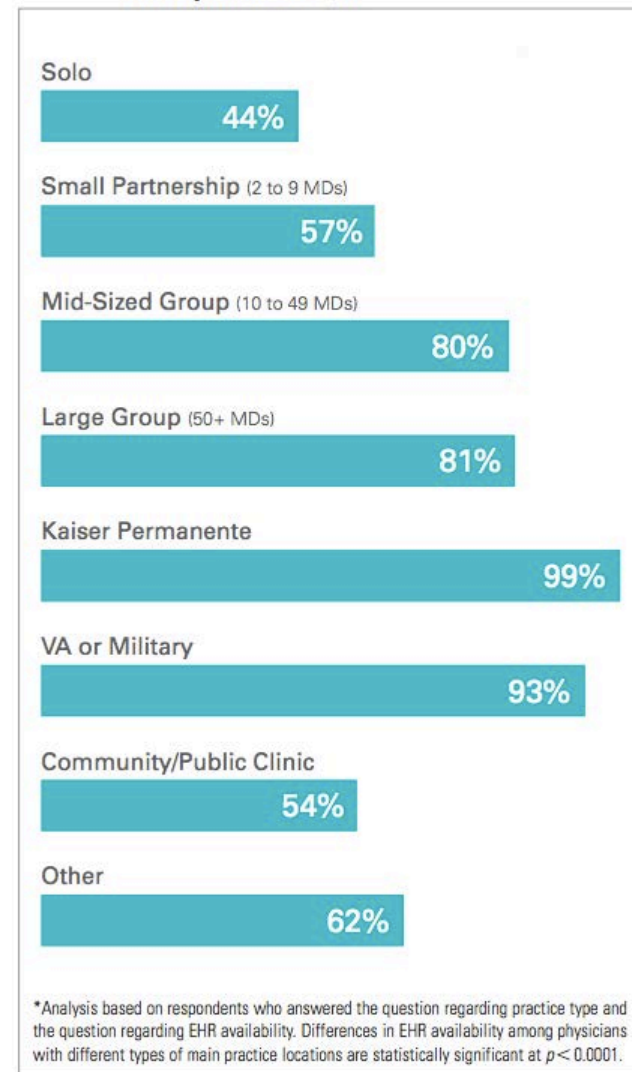

NCVHS, 2011 – US Physicians

EHR Implementation at Physician Practices,
Overall and by Practice Size

Legend: ■ Implemented   ■ Not Implemented   ■ Unknown

All Physicians (n=65,388)
- 48% Implemented | 46% Not Implemented | 7% Unknown

Solo
- 20% | 63% | 16%

2 to 5 MDs
- 39% | 56% | 5%

6 to 50 MDs
- 64% | 33% | 3%

51+ MDs
- 80% | 18% | 1%

CHCF, 2011 – Calif. physicians

Figure 4. EHR Availability, by Practice Type, All Physicians (n=5,004)*

Solo — 44%
Small Partnership (2 to 9 MDs) — 57%
Mid-Sized Group (10 to 49 MDs) — 80%
Large Group (50+ MDs) — 81%
Kaiser Permanente — 99%
VA or Military — 93%
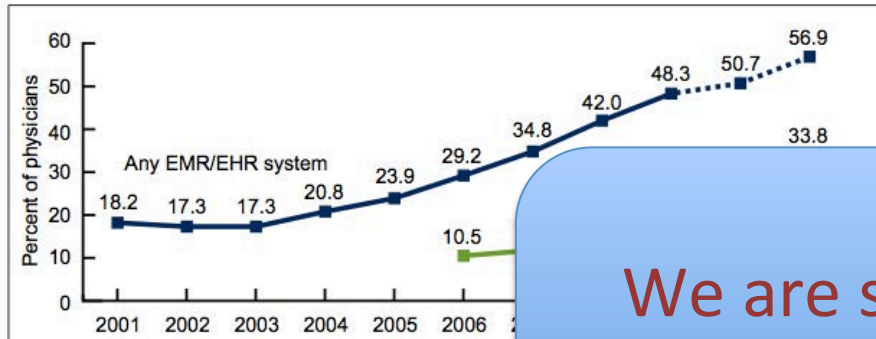Community/Public Clinic — 54%
Other — 62%

*Analysis based on respondents who answered the question regarding practice type and the question regarding EHR availability. Differences in EHR availability among physicians with different types of main practice locations are statistically significant at $p < 0.0001$.

CHCF, 2012 – Calif. physicians
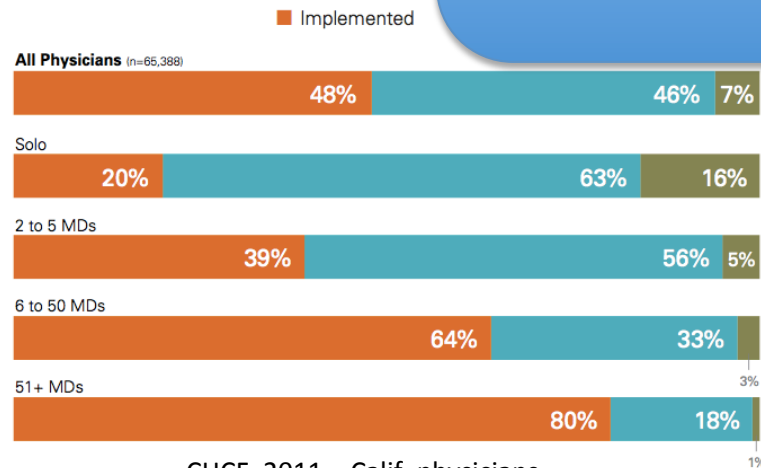
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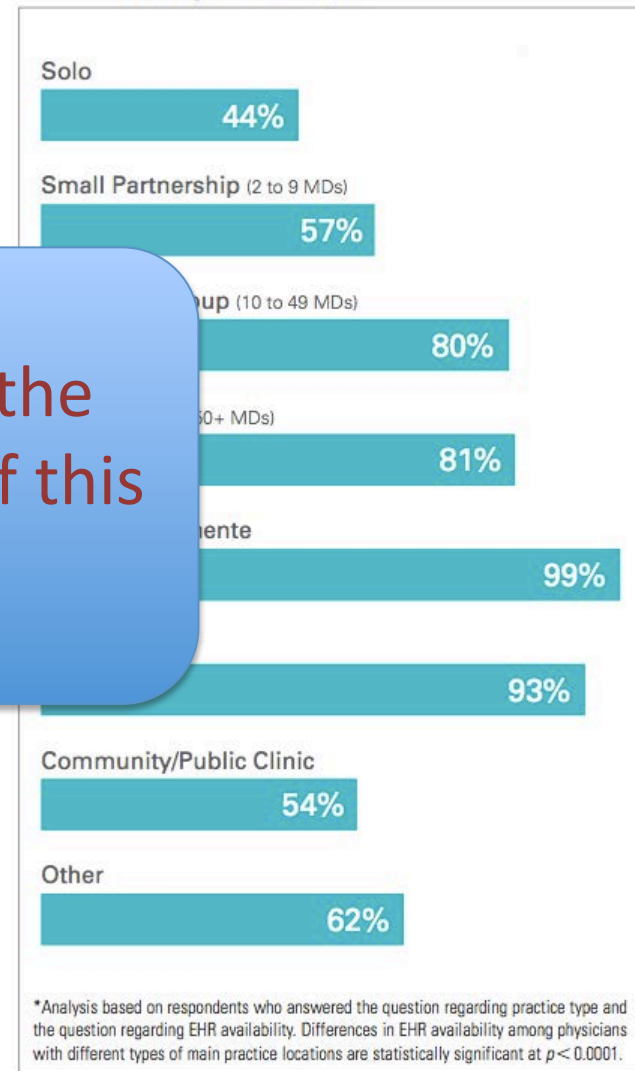
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CHCF, 2012 – Calif. physicians

> We are still at the earliest stages of this revolution!!

The eHealthcare landscape is not flat

US EMR Adoption Model^{SM}

Stage	Cumulative Capabilities	2011 Final	2012 Q1
Stage 7	Complete EMR; CCD transactions to share data; Data warehousing; Data continuity with ED, ambulatory, OP	1.2%	1.2%
Stage 6	Physician documentation (structured templates), full CDSS (variance & compliance), full R-PACS	5.2%	6.2%
Stage 5	Closed loop medication administration	8.4%	9.4%
Stage 4	CPOE, Clinical Decision Support (clinical protocols)	13.2%	13.2%
Stage 3	Nursing/clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology	44.9%	43.9%
Stage 2	CDR, Controlled Medical Vocabulary, CDS, may have Document Imaging; HIE capable	12.4%	12.1%
Stage 1	Ancillaries - Lab, Rad, Pharmacy - All Installed	5.7%	5.5%
Stage 0	All Three Ancillaries Not Installed	9.0%	8.4%

Data from HIMSS Analytics^{TM} Database © 2012   N = 5,337   N = 5,318

What about HIEs? – they are *inevitable*

- Using a hub architecture greatly reduces the number of interfaces to interconnect multiple systems

$31,080,000   **$560,000**

100 practices
6 labs
2 rad prac
4 hospitals

[112(112-1)/2]*$5,000 = $31,080,000   112*$5,000= $560,000

Adding 1 node = $560,000   **Adding 1 node = $5,000**
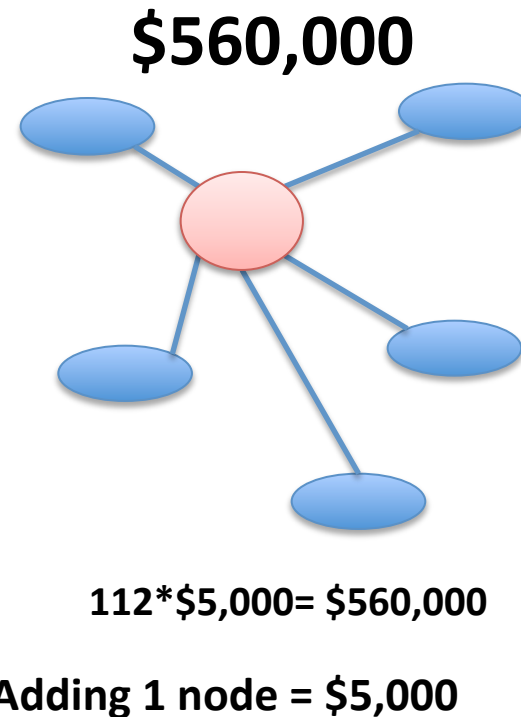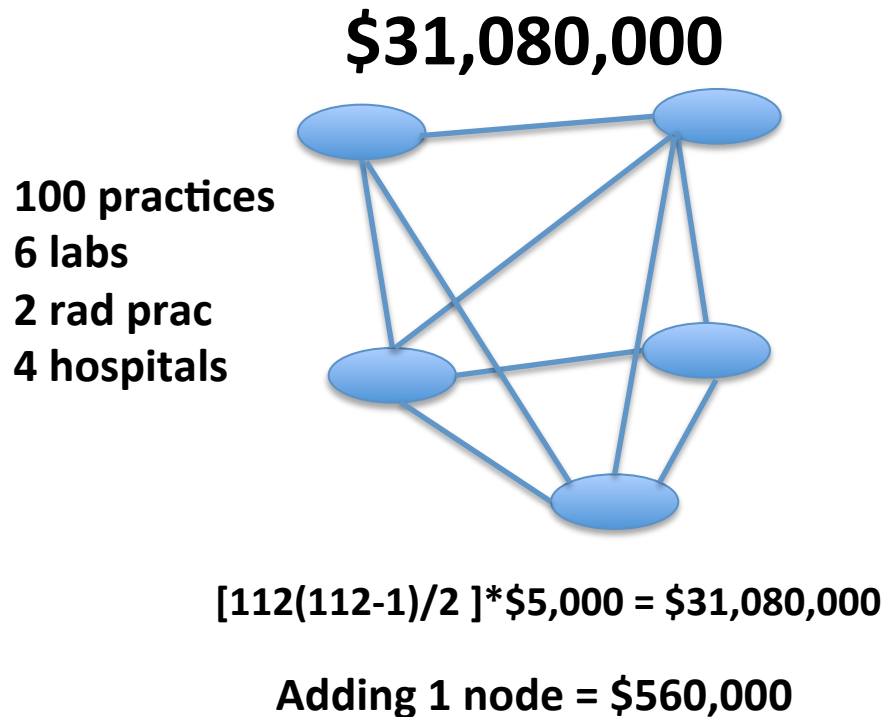
Number of connections needed to connect all nodes in a network without a hub: n(n-1)/2
Number of connections needed to connect nodes through a central hub: n

The next wave -- "Secondary Use"

Health Information Exchange

First Generation

- **"Help us do something better..."**
  - Facilitating activity around diagnosis and treatment
  - Enabling electronic prescribing
  - Electronic orders/results

- Provider to provider, real-time communication and record exchange

Second Generation

- **"Help us understand how we are doing..."**
  - Quality
  - Disease outbreaks
  - Pharmaco-vigilance
  - Disease registries
  - "Patients Like Mine"

- Facilitating population based querying and analytics across multiple EHRs

What will drive this?

- $ Pay for Performance…

- Quality Measurement and Improvement (QI)
  - Within institutions
  - Across institutions (comparative effectiveness?)

- Pharmaco-vigilance
  - "treatment-vigilance"…

- Understanding Disease and its impact
  - Surveillance Registries (cancer)

DSRIP: An experiment in paying for improved quality

http://www.dhcs.ca.gov/provgovpart/Pages/DSRIP1.aspx

Metric	Achievement / Outcome Description	Achievment Value	Achievment Score	Achievment Disbursement ($)
Project 7: Improve Severe Sepsis Detection and Management				
7.1	UCDMC joined the UHC Sepsis Improvement Collaborative and has begun a partnership with the Betty & Gordon Moore Foundation.	1.00	1.00	1,164,625
7.2	UCDMC has convened a multi-disciplinary group to develop goals and work plans for reducing severe sepsis and septic shock mortality.	1.00		
7.3	The UCDMC Sepsis Improvement Collaborative has utilized Lean Six Sigma philosophies and methodology to evaluate current processes and develop process redesign as it relates to sepsis.	1.00		
Project 8: Central Line-Associated Bloodstream Infection (CLABSI) Prevention				
8.1	UCDMC implemented the use of CLIP documentation, utilizing the EHR, during the time period of November 1, 2010 to February 28, 2011.	1.00	1.00	952,875
Project 9: Surgical Site Infection (SSI) Prevention				
9.1	TheraDoc software has been validated and a TheraDoc consultant is on-site for training and finalizing the implementation of processes.	1.00	1.00	952,875
9.2	The plan for surgical site infection (SSI) is in place and a SSI baseline was established for reporting/measurement using NHSN and State of California (mandated by SB 1058) methodology.	1.00		
Project 10: Hospital-acquired Pressure Ulcer (HAPU) Prevention				
10.1	UCDMC has implemented an EHR template for the SWAT team to document wound assessment, including wound photographs.	1.00	1.00	952,875
10.2	An electronic dashboard has been developed with Patient Care Services to measure, report and share HAPU prevalence to inpatient units for awareness and education.	1.00		

Category 4 Total: 4,023,250

DY-6 Total: 44,700,000

Measuring Performance

Bundle 1. Initial measurement of serum lactate level

Percent Compliance vs. Month

Measured — Target
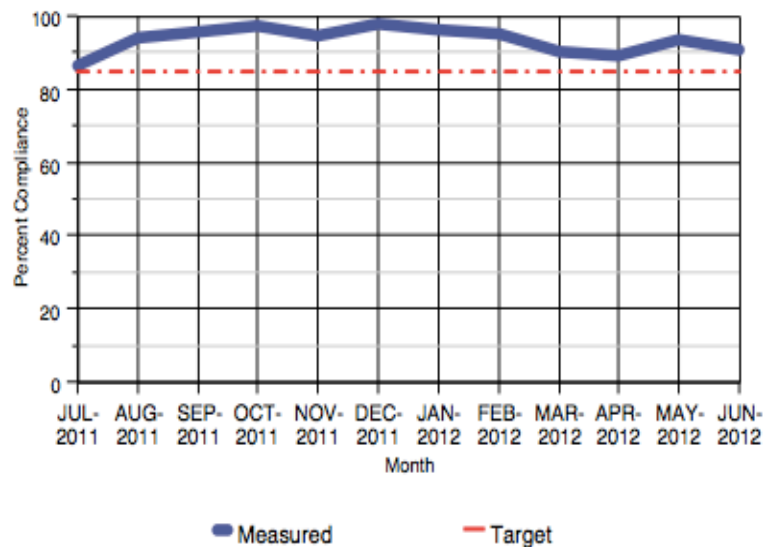
Bundle 2. 20 ml/kg fluid administration in 6 hours

Percent Compliance vs. Month

Measured — Target
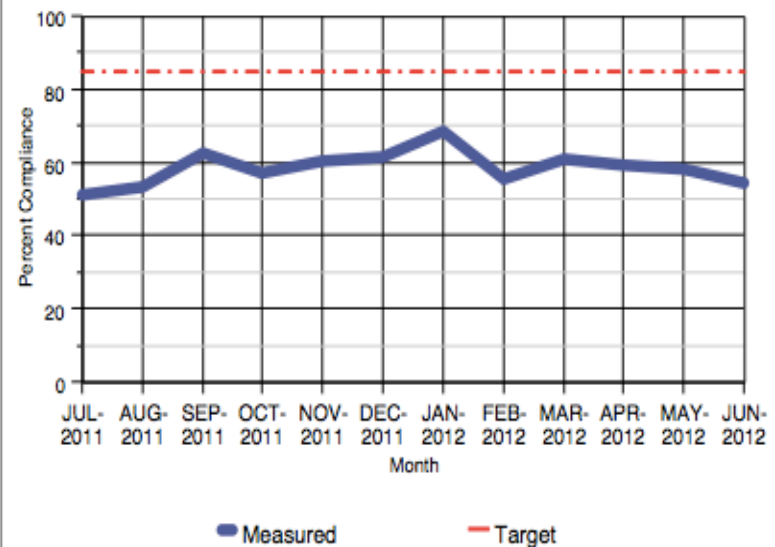
Bundle 3. Blood culture obtained before antibiotics administered

Percent Compliance vs. Month

Measured — Target
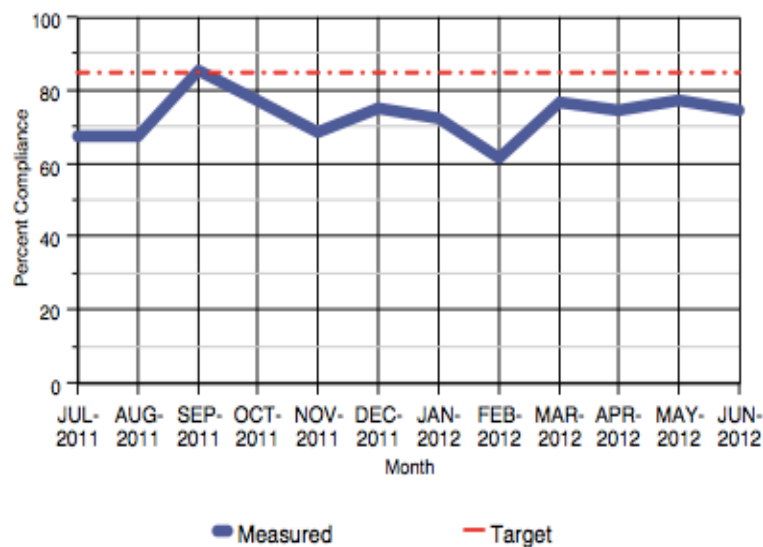
Bundle 4. Initial antibiotic administration in appropriate time frame

Percent Compliance vs. Month

Measured — Target
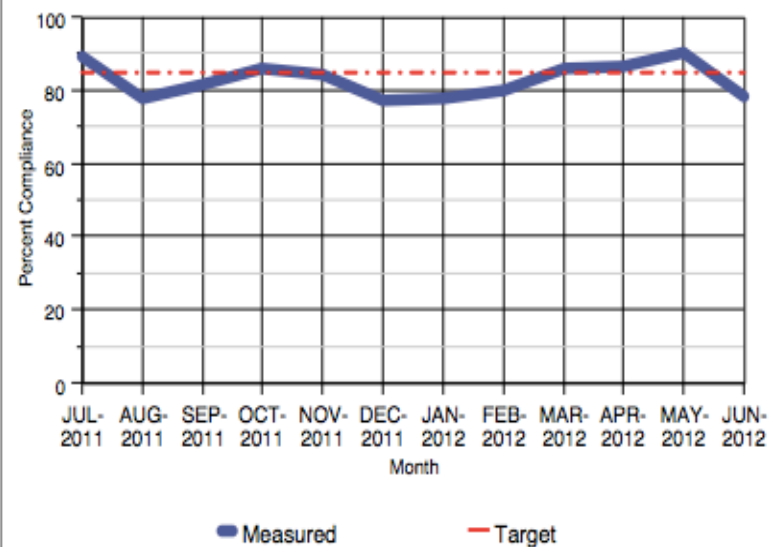
Understanding Disease:
Surveillance Registries

Pharmaco-vigilance:
The COX-2 Inhibitor Story

New drug classes

COX-2 inhibitors

C J Hawkey

In the past 100 years aspirin has demonstrated its value as an analgesic, anti-inflammatory, and antithrombotic agent. However, by 1938, it was clear that aspirin was gastrotoxic. Non-steroidal anti-inflammatory drugs (NSAIDs), developed since the 1960s, failed to achieve the goal of "a safer aspirin". The demonstration that inhibition of prostaglandin synthesis via a cyclo-oxygenase (COX) enzyme was central to both the therapeutic and toxic effects of aspirin and non-aspirin NSAIDs appeared to establish the principle of no gain without pain. This link may have been broken by drugs that selectively inhibit the inducible COX-2 enzyme. The COX enzyme is now a target of drug interventions against the inflammatory process. Might the "safe aspirin" be here at last?

Before the discovery of COX-2, cyclo-oxygenases were believed to be expressed constitutively with constant levels in individual tissues; prostaglandin synthesis was believed to increase in inflammation because of increased release of precursor. However, cyclo-oxygenase activity increases in inflammation, and this increase can be prevented by corticosteroids. From these clues, two different approaches identified a new inducible isoform (COX-2). Needleman's group detected a different cyclo-oxygenase protein in monocytes stimulated by interleukin 1.[1] A molecular programme, designed to identify inducible immediate-early-response genes, yielded one with considerable sequence homology with the known (COX-1) gene.[2] Recognition that there were two cyclo-oxygenase isoforms vitalised a second attempt by the pharmaceutical industry to identify "a safer

to be the site of binding of many selective drugs (figure 2). The bulkier isoleucine at 523 in COX-1 is large enough to block access to the side-pocket. Targeted single aminoacid substitution of valine for isoleucine is sufficient to turn COX-1 into an enzyme that can be inhibited by COX-2 selective agents.[4,6]

The value of this understanding for logical drug development is best illustrated by a series based on flurbiprofen.[6] Progressive modification and extension of flurbiprofen's methyl group resulted in molecules that were increasingly selective in their ability to bind in the COX-2 side-pocket, but too bulky to fit within the COX-1 channel (figure 2 and table 1). Many COX-2
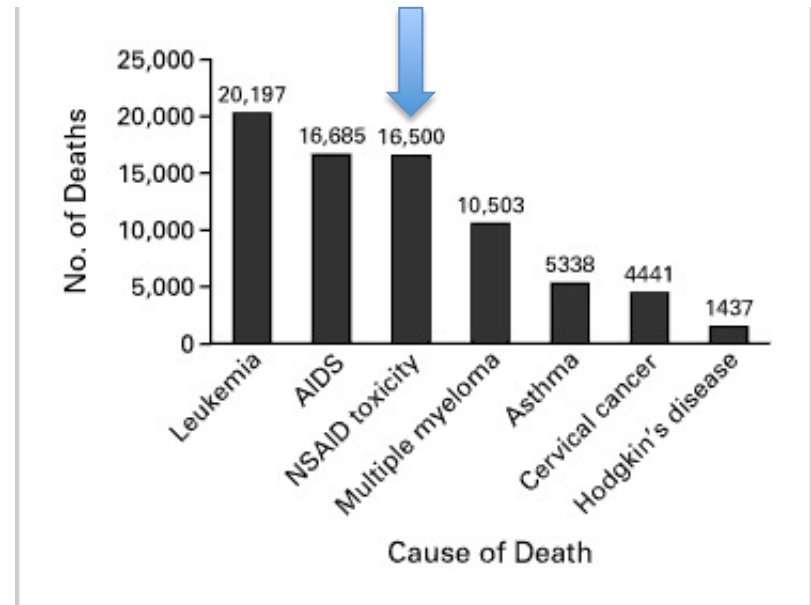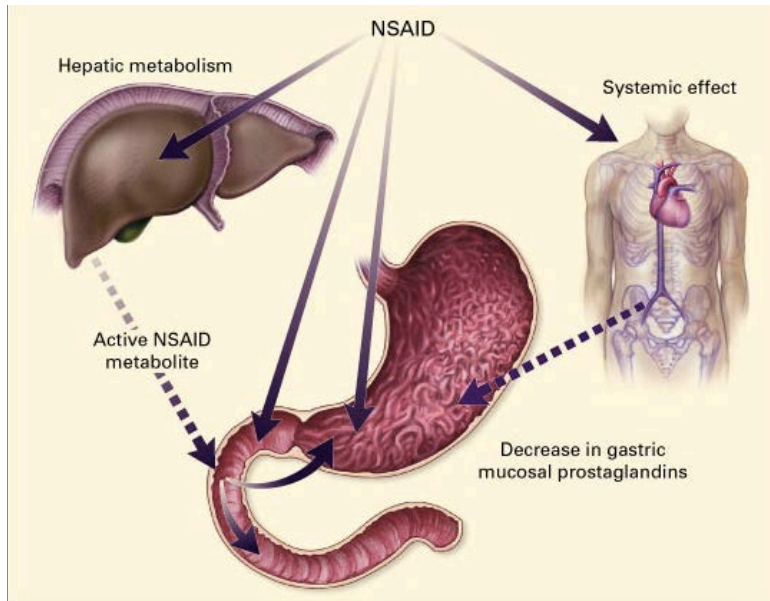
COX-2 Inhibitors – gastric side effects

Figure 1. U.S. Mortality Data for Seven Selected Disorders in 1997.

A total of 16,500 patients with rheumatoid arthritis or osteoarthritis died from the gastrointestinal toxic effects of NSAIDs. Data are from the National Center for Health Statistics and the Arthritis, Rheumatism, and Aging Medical Information System.12

The New England Journal of Medicine

COMPARISON OF UPPER GASTROINTESTINAL TOXICITY OF ROFECOXIB AND NAPROXEN IN PATIENTS WITH RHEUMATOID ARTHRITIS

Claire Bombardier, M.D., Loren Laine, M.D., Alise Reicin, M.D., Deborah Shapiro, Dr.P.H., Ruben Burgos-Vargas, M.D., Barry Davis, M.D., Ph.D., Richard Day, M.D., Marcos Bosi Ferraz, M.D., Ph.D., Christopher J. Hawkey, M.D., Marc C. Hochberg, M.D., Tore K. Kvien, M.D., and Thomas J. Schnitzer, M.D., Ph.D., for the VIGOR Study Group

November 23, 2000

An Unexpected Finding

Risk of acute myocardial infarction and sudden cardiac death in patients treated with cyclo-oxygenase 2 selective and non-selective non-steroidal anti-inflammatory drugs: nested case-control study

David J Graham, David Campen

Summary
Background Controversy ... decreases the risk of se... either high or standard ... use, because celecoxib v...

"...an unexpected finding was a five-fold higher risk of myocardial infarction in the rofecoxib group"

Rofecoxib and celecoxib, the first two drugs ... coxib class of NSAIDs, were approved by the U... Drug Administration (FDA) in 1999. Their laur... lowed rapidly by the publication of two large ... trials aimed at proving the concept of improve... safety. The VIGOR study[3] compared rofecoxib with naproxen in patients with rheumatoid arthritis and showed that rofecoxib halved the number of clinically relevant upper gastrointestinal events. However, an unexpected finding was a five-fold higher risk of myocardial infarction in the rofecoxib group, which posed an obvious threat to an otherwise excellent result. Although not a prespecified outcome, and potentially a chance finding, this result was an important signal that generated two important hypotheses: that naproxen has cardioprotective effects or that rofecoxib promotes adverse cardiovascular outcomes. The former was based on the concept that naproxen might be cardioprotective because of its inhibition of thromboxane production and platelet aggregation, although there was little reliable evidence to support this view.

Risk of Cardiovascular Events Associated With Selective COX-2 Inhibitors

Debabrata Mukherjee, MD
Steven E. Nissen, MD
Eric J. Topol, MD

Atherosclerosis is a process with inflammatory features and selective cyclooxygenase 2 (COX-2) inhibitors may potentially have antiatherogenic effects by virtue of inhibiting inflammation. However, by decreasing vasodi-

Figure 1. Cumulative sum (CUSUM) chart of monthly incidence of hospitalizations due to myocardial infarction from January 1, 1997 to March 30, 2006.

CUSUM = Cummulative Sum
Measures the mean change in a value of interest over time
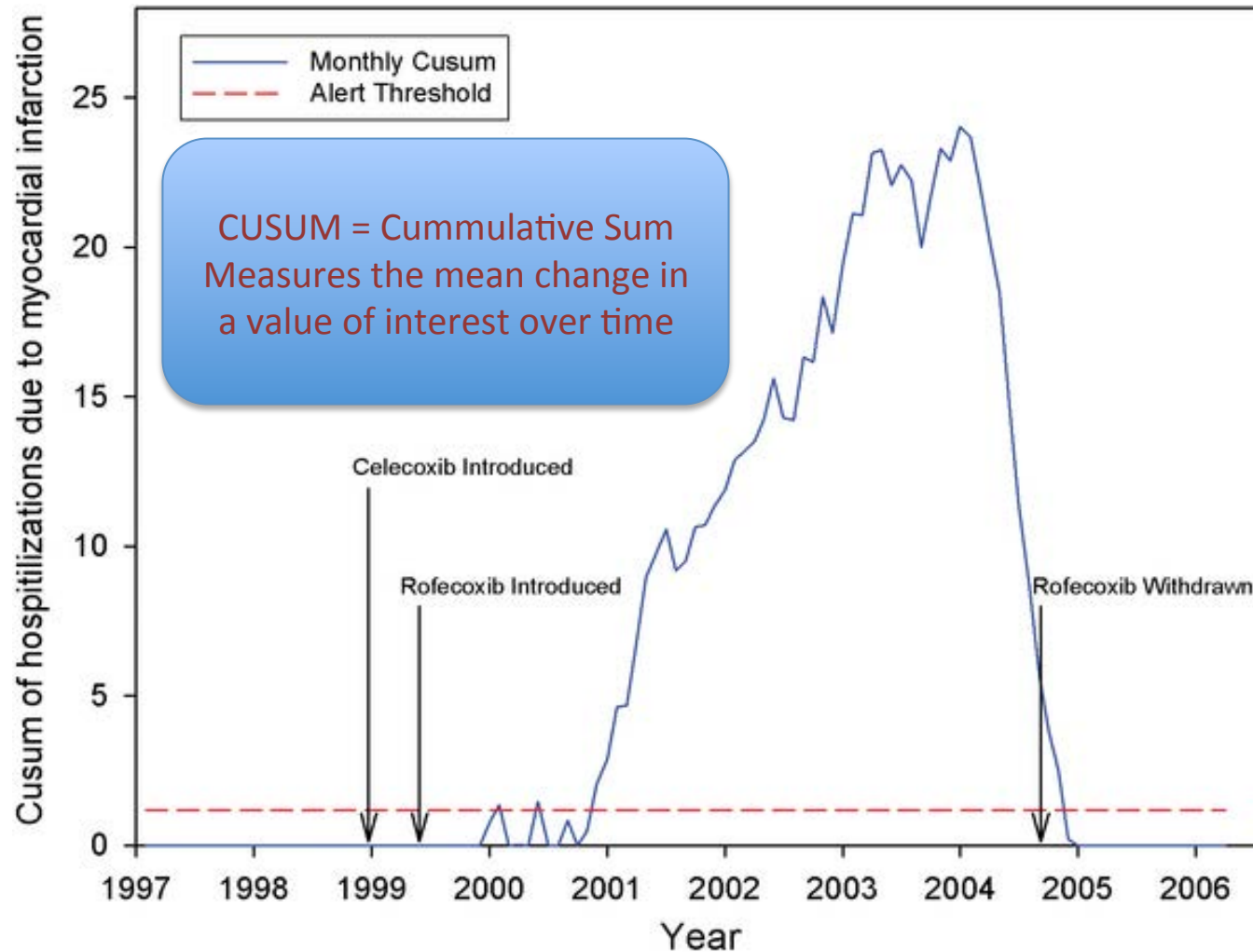
Data:

Partners Research Patient Data Registry

PLoS one

Figure 3. Association between yearly prescriptions for rofecoxib and celecoxib and mean age of patients hospitalized for myocardial infarctions.
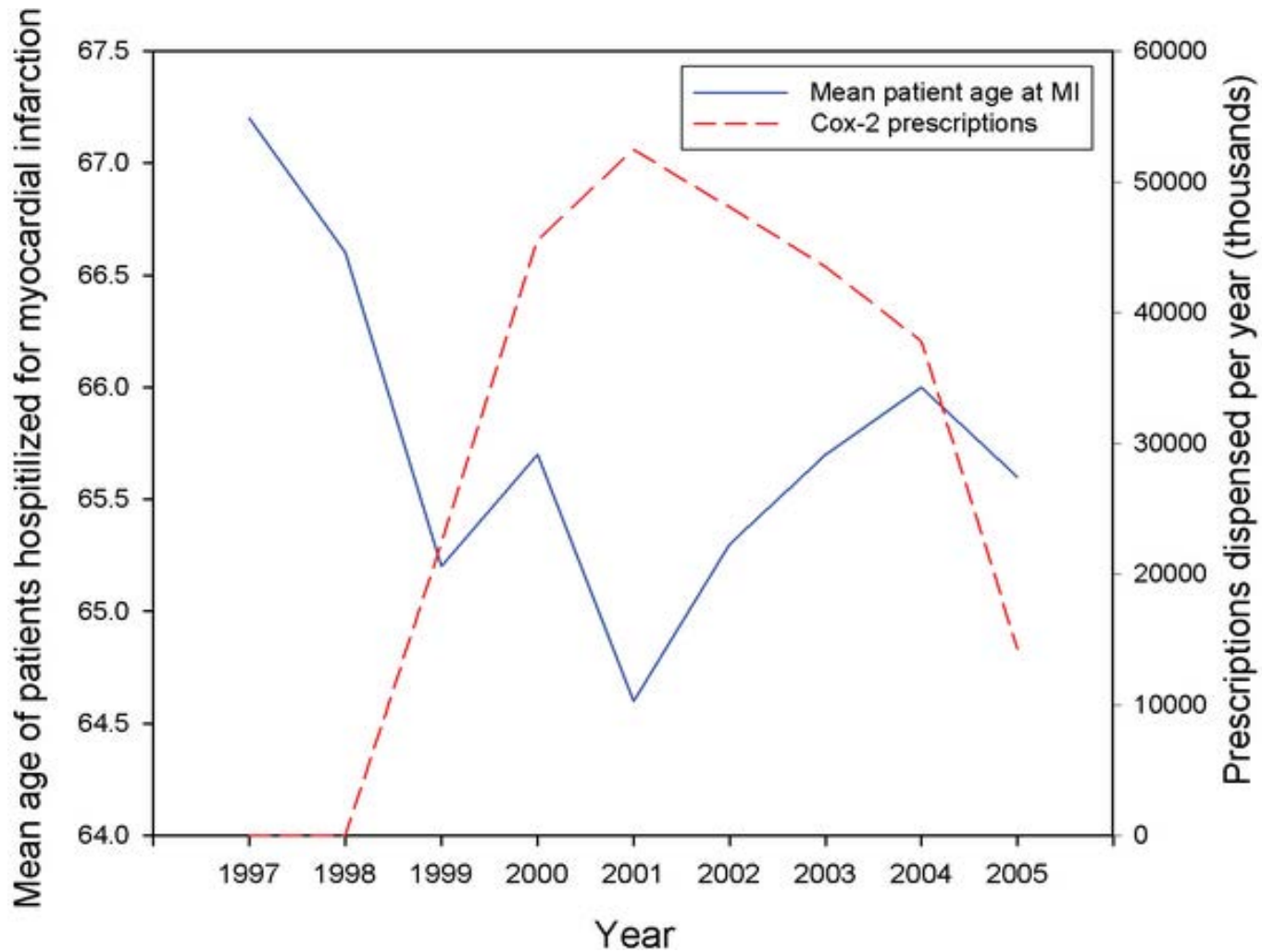
Comparing treatment strategies for complex cases: "Patients Like Mine"

- 13 yr old patient with SLE, nephrosis, and acutely ill with pancreatitis, also had +APL – high risk of thrombus

- No studies on use of preventive anticoagulation in this situation

- Queried Stanford's STRIDE clinical (98 SLE patients in the database: 2004-2009)

The **NEW ENGLAND JOURNAL** *of* **MEDICINE**

Evidence-Based Medicine in the EMR Era

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

Many physicians take great pride in the practice of evidence-based medicine. Modern medical education emphasizes the value of the randomized, controlled trial, and we learn early on not to rely on approach, using the data captured in our institution's electronic medical record (EMR) and an innovative research data warehouse. The platform, called the Stanford

NEJM. Nov 3, 2011

Comparing treatment strategies for complex cases: "Patients Like Mine"

- 13 yr old patient with SLE, nephrosis, and acutely ill with pancreatitis, also had +APL – hi

- No studi preventi in this si

- Queried clinical (the data

- ~3 million records (Stanford STRIDE)
- 4hrs of querying and analysis with standard tools
- Results – 18 patients like this...
  - SLE+pancreatitis = 11.8 times more likely to suffer a thrombus
  - SLE related nephrotic syndrome = 14.7 times more likely to suffer a thrombus
  - Decision: Anti-coagulate

NEW ENGLAND JOURNAL *of* MEDICINE

M. Sutherland, M.D.

actice   approach, using the data captured
dical   in our institution's electronic med-
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ly on   tive research data warehouse. The
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Large scale data sets: eICU Research Repository

Benchmark Data From More Than 240,000 Adults That Reflect the Current Practice of Critical Care in the United States

Craig M. Lilly, MD, FCCP; Ilene H. Zuckerman, PharmD, PhD; Omar Badawi, PharmD; and Richard R. Riker, MD, FCCP

Background: Nationwide benchmarks representing current critical care practice for the range of ICUs are lacking. This information may highlight opportunities for care improvement and allows comparison of ICU practice data.
Methods: Data representing 243,553 adult admissions from 271 ICUs and 188 US nonfederal hospitals during 2008 were analyzed using the eICU Research Institute clinical practice database. Participating ICUs and hospitals varied widely regarding bed number, community size, academic status, geographic location, and organizational structure.
Results: More than one-half of these critically ill adults were <65 years old, and most patients returned to their homes after hospital discharge. Most patients were admitted from an ED, had a medical admission diagnosis, and received antimicrobial therapy. Intensive treatment was common, including 27% who received mechanical ventilation, 7.5% who were supported with noninvasive ventilation, 24.3% who were treated with vasoactive infusions, >20% who received a blood product, and 4.4% who agreed to a care limitation order during their ICU stay. Forty percent of cases had a <10% mortality risk and did not have an intensive treatment documented.
Conclusions: Admission to an ICU in 2008 involved active treatments that often included life support and counseling for those near the end of life and was associated with favorable outcomes for most patients. **CHEST 2011; 140(5):1232–1242**

Abbreviations: ALI = acute lung injury; APACHE = Acute Physiology and Chronic Health Evaluation; DNR = do not resuscitate; eRI = eICU Research Institute; IQR = interquartile range; LOS = length of stay; SMR = standardized mortality ratio

Table 1. eICU Research Institute database characteristics.	
Descriptor	**Quantification**
Health-system demographics	
Health systems	32
Hospitals	188
ICUs and step-down units	356
ICU stays/patients	
Total ICU admissions in database	1,013,706
Total ICU admissions in 2008	273,270
Total ICU admissions added per quarter	70,083
Stay characteristics	
Average ICU length of stay	2 days
Average hospital length of stay	7 days
Percentage patients with a single stay	95
Basic outcome characteristics	
Percentage stays resulting in death in ICU	5
Percentage stays resulting in death in hospital	14
Data characteristics	
Total laboratories	>200,000,000
Total medications	>20,000,000
Total diagnoses	>8,000,000
Total vital sign measurements	>600,000,000

"Support for such a wide range of potential investigations requires the amalgamation of clinical data from multiple sources into a single, unified corpus from which subset data can be easily and quickly retrieved"

Understanding Current State of Practice

Table 4—Best Practice Adherence

Practice	All (N = 243,553)	Medical (n = 17,154)	Surgical (n = 15,993)	Mixed (n = 115,977)	Coronary Care (n = 56,138)	CV Surgical (n = 27,839)	Trauma (n = 861)	Neuro (n = 9,591)
Stress ulcer prevention (No. = at risk)[a]	33,168	2,567	1,886	17,487	6,786	3,058	71	1,313
Treated, No. (% adherent)	30,127 (90.8)	2,371 (92.4)	1,720 (91.2)	15,775 (90.2)	6,214 (91.6)	2,767 (90.5)	65 (91.5)	1,215 (92.5)
VTE prevention (No. = at risk)[a]	151,297	10,950	10,096	73,528	33,415	15,923	473	6,912
Treated, No. (% adherent)	131,393 (86.8)	10,054 (91.8)	8,864 (87.8)	63,693 (86.6)	28,206 (84.4)	13,543 (85.1)	430 (90.9)	6,603 (95.5)
Medication	37,500	2,910	1,079	18,948	8,639	5,349	180	395
Device	50,611	3,905	4,569	23,276	10,432	3,495	113	4,821
Both	43,282	3,239	3,216	21,469	9,135	4,699	137	1,387
Within 24 h	121,339	9,395	8,357	58,468	26,064	12,425	367	6,263
24-48 h	6,800	474	331	3,479	1,445	781	35	255
After 48 h	3,254	185	176	1,746	697	337	28	85
β-Blocker use[a]								
ACS, treated/at-risk (% adherent)	12,577/15,920 (79)	313/454 (68.9)	195/248 (78.6)	4,297/5,512 (78)	5,242/6,748 (77.7)	2,449/2,862 (85.6)	...	81/96 (84.4)
Vascular surgery, treated/at-risk	3,411/5,023 (69.6)	23/32 (71.9)	851/1,094 (77.8)	1,150/1,909 (60.2)	431/630 (70.4)	431/630 (68.4)	...	33/46 (71.7)
Nonvascular surgery, treated/at-risk	1,480/2,127 (67.9)	33/48 (68.8)	260/351 (74.1)	630/925 (68.1)	204/295 (64.6)	204/295 (69.1)	...	104/124 (83.9)
Low tidal volume ventilation (No. = ABGs from ARDS/ALI)	12,466	931	1,022	6,489	3,131	595	195	103
<6 mL/kg, No. (% of ABGs)	3,512 (28.2)	276 (29.6)	391 (38.3)	1,914 (29.5)	706 (22.5)	168 (28.2)	57 (29.2)	0 (0)
6-8 mL/kg, No. (% of ABGs)	4,760 (38.2)	374 (40.2)	361 (35.3)	2,582 (39.8)	1,193 (38.1)	147 (24.7)	82 (42.1)	21 (20.4)
>8 mL/kg, No. (% of ABGs)	4,194 (33.6)	281 (30.2)	270 (26.4)	1,993 (30.7)	1,232 (39.3)	280 (47.1)	56 (28.7)	82 (79.6)
Glycemic control (No. = patient days)	378,959	26,923	24,576	179,470	86,270	45,525	1,286	14,909
Average daily glucose ≤110 mg/dL	101,781 (26.9)	7,434 (27.6)	6,021 (24.5)	48,157 (26.8)	23,199 (26.9)	12,666 (27.8)	463 (36)	3,841 (25.8)
Average daily glucose 111-150 mg/dL	138,287 (36.5)	9,134 (33.9)	9,668 (39.3)	64,062 (35.7)	31,920 (37)	17,348 (38.1)	458 (35.6)	5,697 (38.2)
Average daily glucose 151-180 mg/dL	75,060 (19.8)	5,357 (19.9)	5,060 (20.6)	35,641 (19.9)	16,899 (19.6)	8,763 (19.2)	215 (16.7)	3,125 (21)
Average daily glucose >180 mg/dL	63,831 (16.8)	4,998 (18.6)	3,827 (15.6)	31,610 (17.6)	14,252 (16.5)	6,748 (14.8)	150 (11.7)	2,246 (15.1)

Data are given as No. (%) unless otherwise indicated. ... = qualifying case numbers not sufficient. ABG = arterial blood gas; ACS = acute coronary syndrome; ALI = acute lung injury. See Table 1 legend for expansion of other abbreviations.

[a]Adherent/at risk after exclusion of cases with contraindications (%); cases ventilated for >24 h were considered at risk.

What will the future bring?

- Multiple clinical data repositories (CRs) across the healthcare community

- With many patients, a 360 degree view of their healthcare is only possible with data from multiple repositories

- Improving care will require us to measure what we are doing – **within and across healthcare institutions**
  - If you can't measure what you are doing, you can't improve it.

Why Clinical Repositories vs. EHRs?

- EHR's don't always have all the institutional information about the patient
  - EHRs are a significant source of information but not the only one

- EHR's are transactional systems, not designed for 'aggregated querying'

- Even with excellent EHRs and ancillary systems, we still require **data curation** and **semantic harmonization** to provide a highest quality data set

Why HIE's?

- They are in place and with existing organizational relationships to enable data sharing, harmonization, etc…

- HIE's will have the 'tracks' required for the information to flow – it will just mean different 'stations' (repository vs. EHR)

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Informatics—UC ReX

OVERVIEW

The UC-Research eXchange (UC-ReX) Informatics consortium will build the first cross-campus clinical query system capable of exchanging patient-level data as well as aggregates (counts and descriptive statistics) across five different UC Medical Centers, as well as some of their key partner institutions. It will do so by leveraging existing clinical data warehouses and building a scalable production system that utilizes state-of-the-art technology and management practices. The initiative requires expertise in information technology (IT) and informatics for software and content development, respectively. It requires concept matching at the semantic level across several institutions, large-scale software implementation experience, and development of a robust governance, management, and training cross-campus informatics infrastructure. The system will be developed to be flexible and quickly adaptable to new technologies and evolving user requirements.

GOALS and OBJECTIVES

Enable researchers and quality improvement specialists to query clinical data collected at the point of care at all UC campuses for research or quality improvement purposes under a common cross-institutional IRB approval process.

LEADERSHIP
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UC-REX SHRINE Network
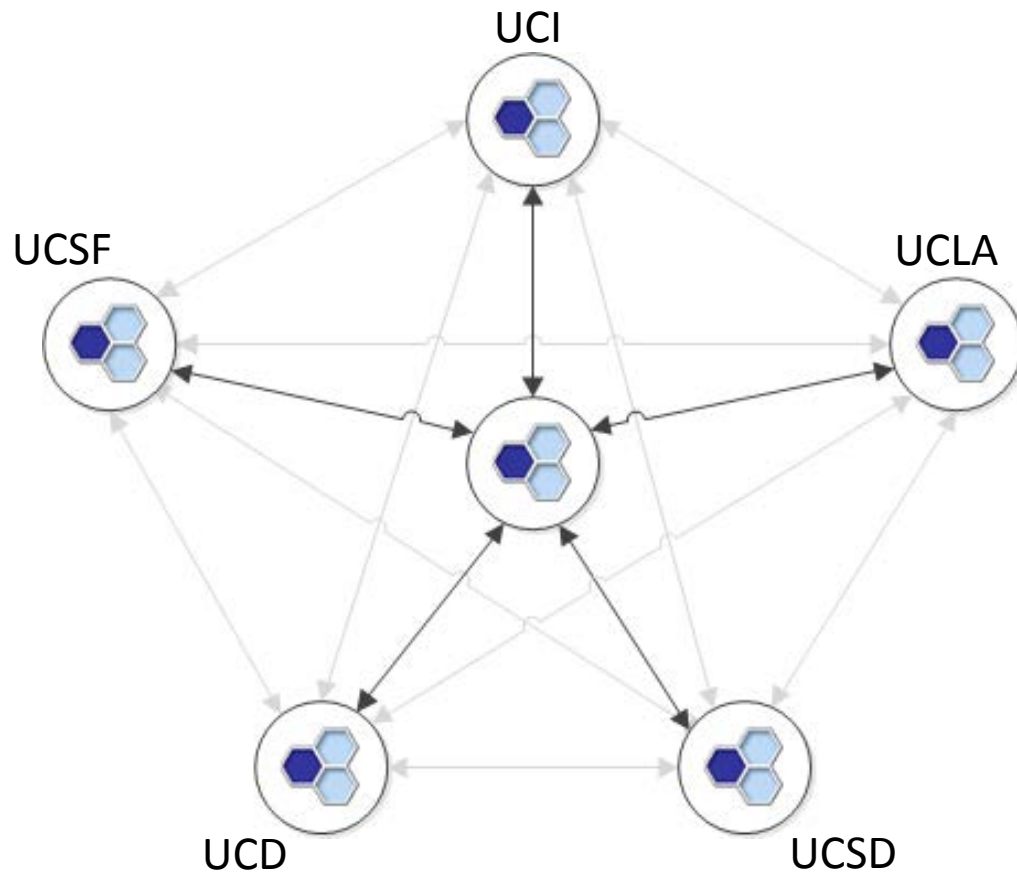
- A collection of i2b2 nodes in a peer-to-peer network

- Nodes forward query messages back and forth, but do not otherwise communicate

Central Management Node

Provide a central point that facilitates the running and management of the UCReX-SHRINE network.

- Status monitoring
  - Heartbeat status reports
  - Alert users if a node needs attention
  - Access to server log files
- Node management
  - Add nodes to network
  - Update SHRINE configuration files remotely
  - Restart SHRINE
- Reviewing query history
  - Gather request data from each individual node
  - An interface to search the combined query history

- Other SHRINE diagnostics
  - Uptime
  - Response time
  - Usage patterns
- Upgrade agents remotely
  - Check to see if an agent SHRINE is the latest version
  - Download and automatically install new agent
- Upgrade SHRINE
  - Usually a long process for each node
  - A single script could be used to deploy SHRINE across all nodes in the network

Central Management Node

UC-ReX: Privacy Considerations

- Data in the repositories is de-identified (i2b2 identifier, no names)

- Queries returning less than 10 count are not performed

- Patients older than 89 are excluded from queries

UC-ReX SHRINE (real data): Jul 20, 2012

UC-ReX SHRINE – Brain cancer

UCReX-SHRINE (total counts: Jul 2012)

	PATIENT DIMENSION	OBSERVATION_FACT
UCSD	2,156,004	21,013,128
UCI	1,426,986	25,130,449
UCSF	2,974,048	142,721,257
UCD	1,935,972	37,048,141
UCLA	in progress	in progress
TOTAL	**8,493,010**	**225,912,975**

UC-ReX Governance

Technical Implementation
- Ensure that infrastructure & critical software are deployed & maintained

Data Harmonization
- Ensure semantic interoperability

User Support
- Define processes, create SOPs
- Planning/coordinating training & user support

Technology Strategy
- Specify use cases
- Provide functional gap analysis

SMART enabling i2b2

Query Health

Query Health = Emerging Distributed Querying Specifications
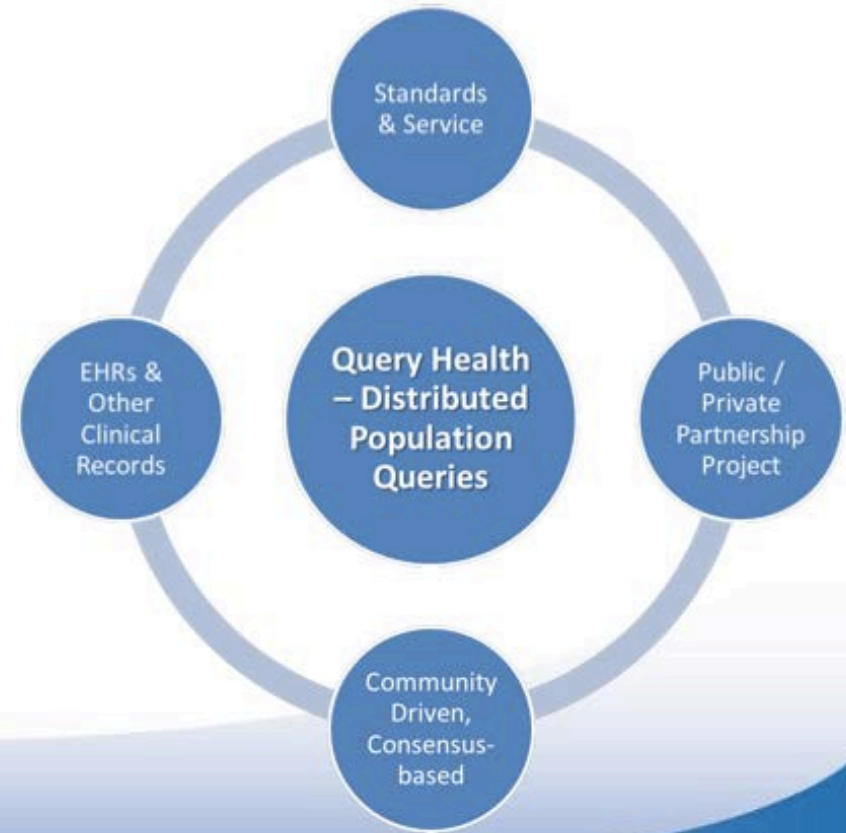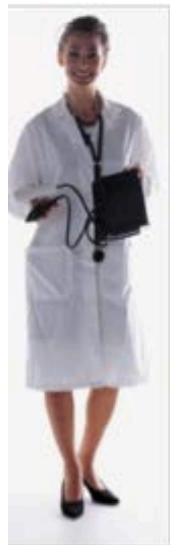
Query Health

Challenges

http://wiki.siframework.org/file/view/Distributed+Population+Queries+-+Query+Health+Launch.pdf
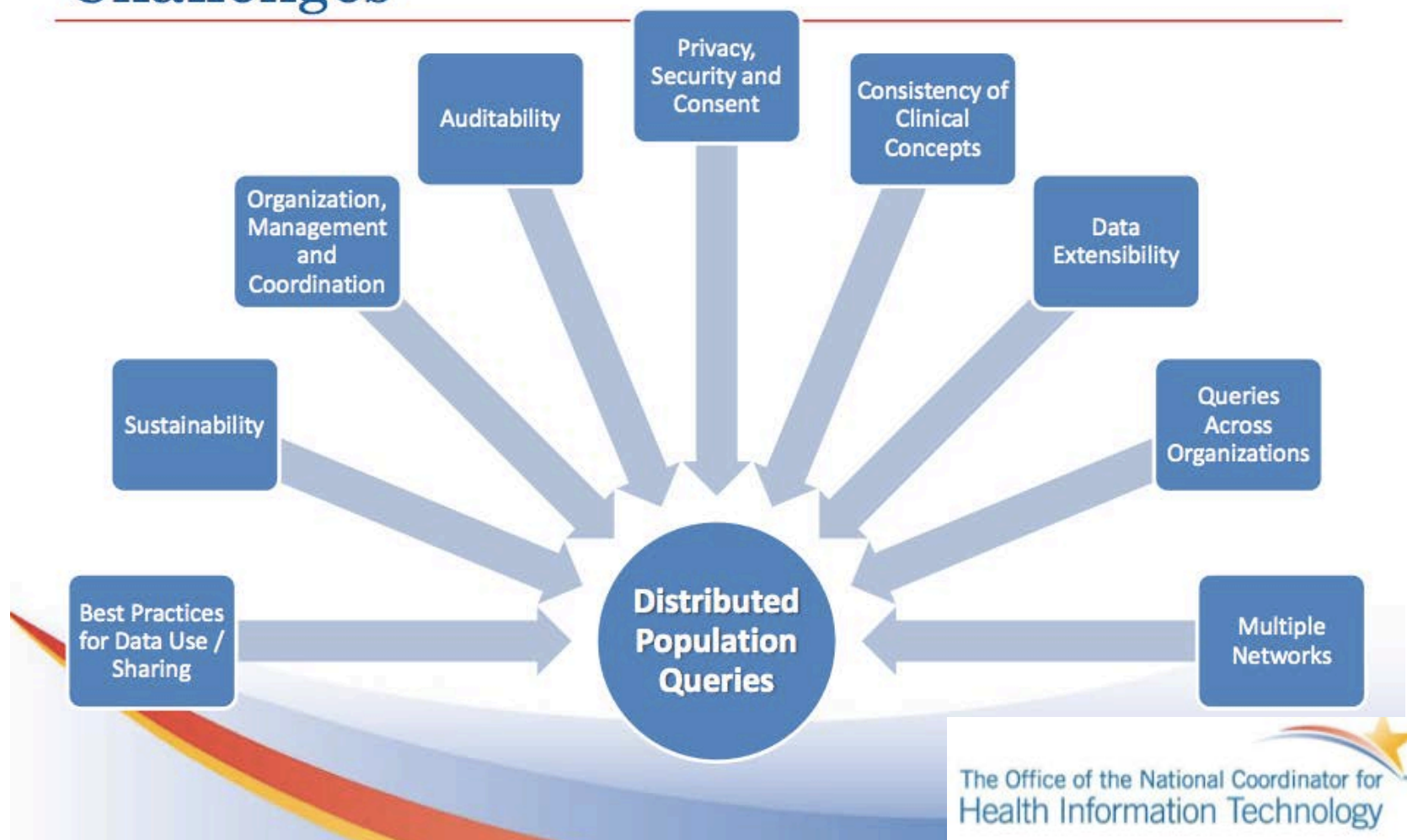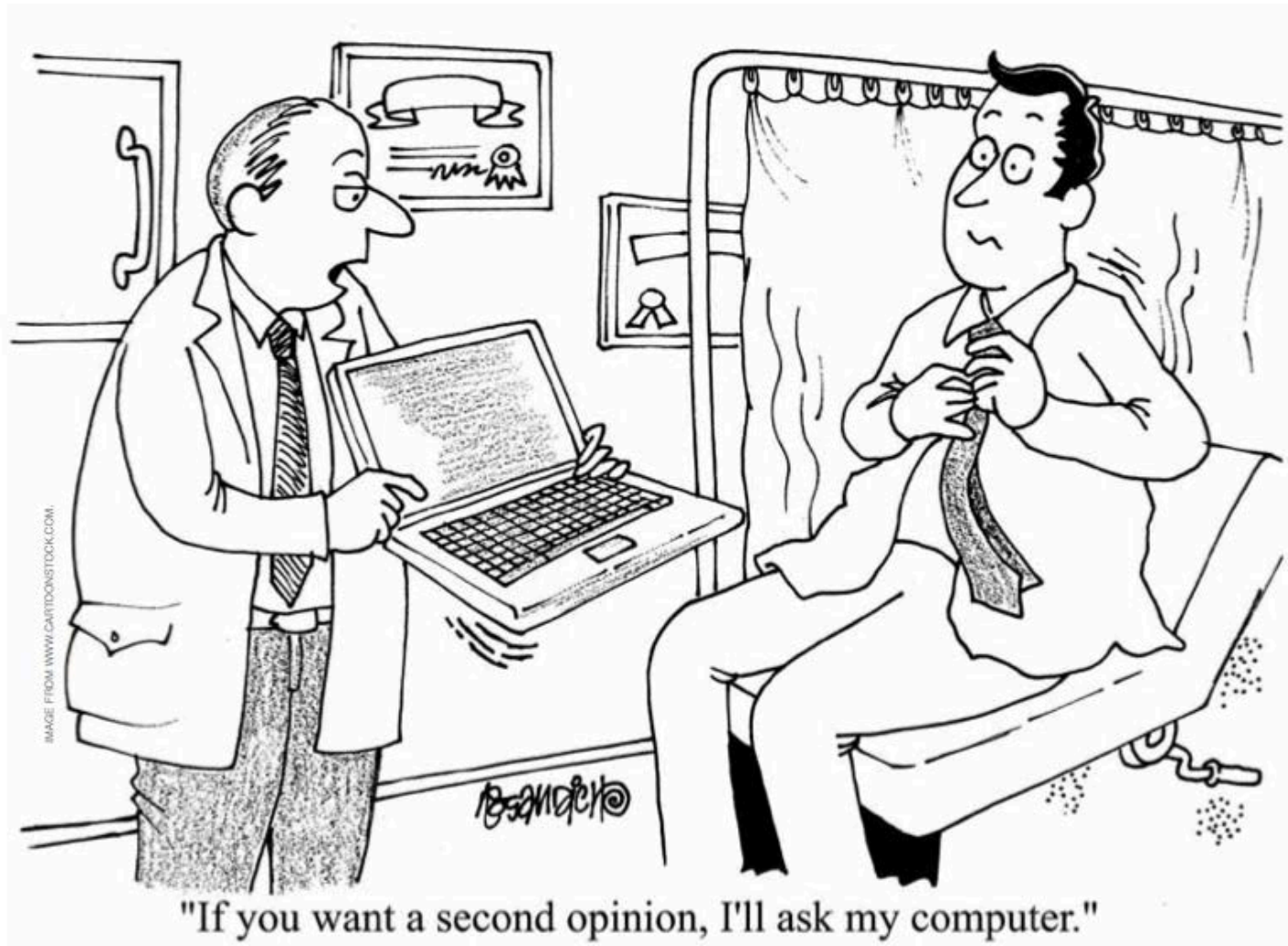
"If you want a second opinion, I'll ask my computer."

Questions?