Artificial intelligence, block chain and beyond

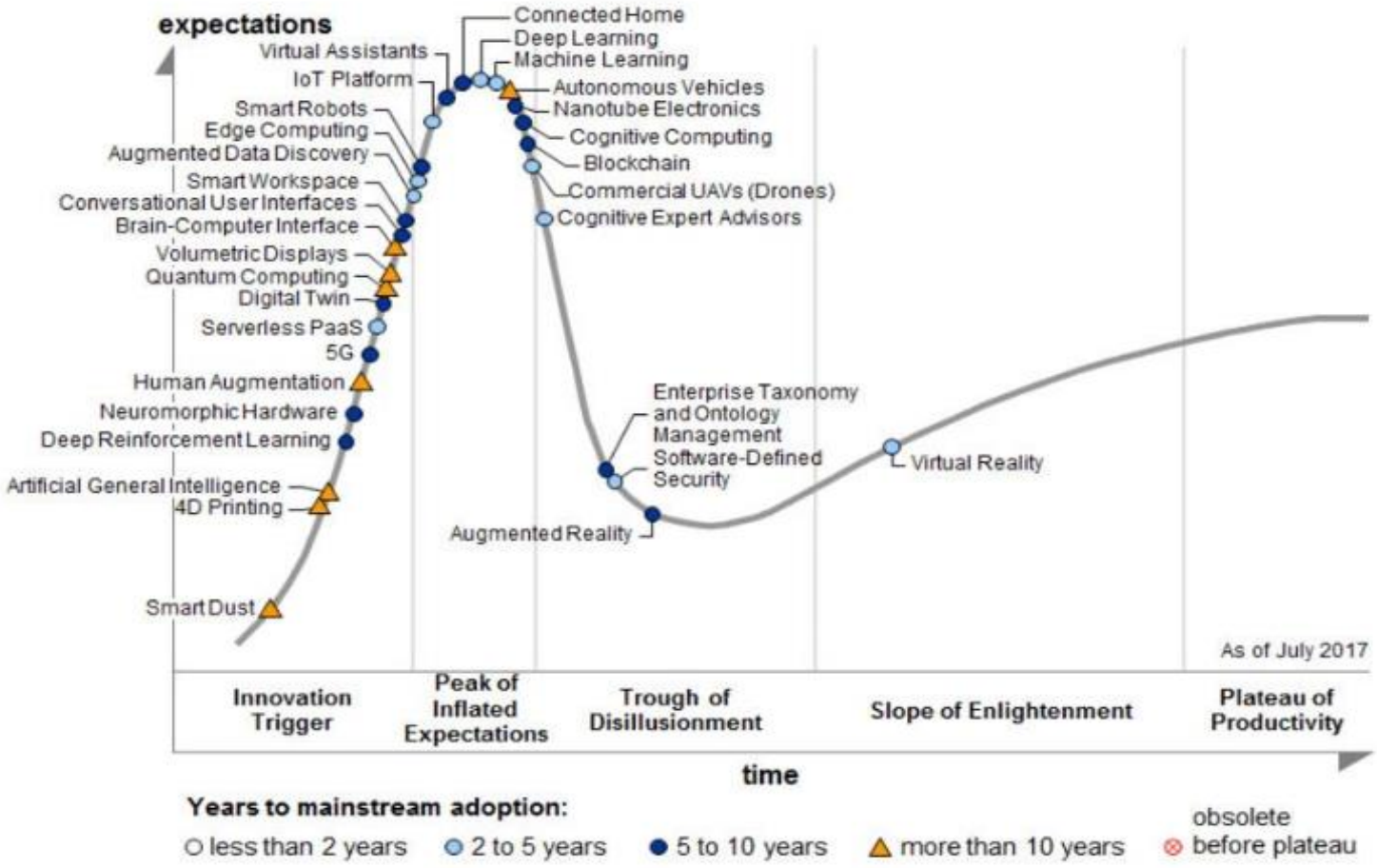
John Glaser, Ph.D.

Senior Vice President

The Leadership Institute | October 18, 2018

Technologies to be discussed

Hype Cycle for Emerging Technologies, 2017



- Artificial intelligence
- Blockchain
- Internet of things
- Big data

Note: PaaS = platform as a service; UAVs = unmanned aerial vehicles

Source: Gartner (July 2017)

Artificial intelligence

Smart navigation

Smart cars

“Intelligence” is already prevalent in our everyday lives

Smart homes

Smart services

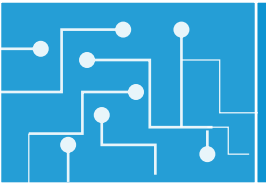
Intelligence has been part of EHRs for years

Decision support that critiques orders

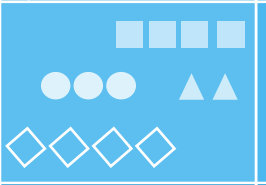
Documentation tailored to a patient's condition

Care process models that guide workflow and care processes

Surveillance that detects critical situations
e.g., sepsis



Predictive models
e.g., readmission risk



Logic that stratifies populations into meaningful cohorts

Analytics that enable organizations to measure cost and quality

Pursuing the next generation of intelligence

Data extraction

Natural language processing | Image | Video

Cognitive interaction

Provider | Consumer

Operational process modeling

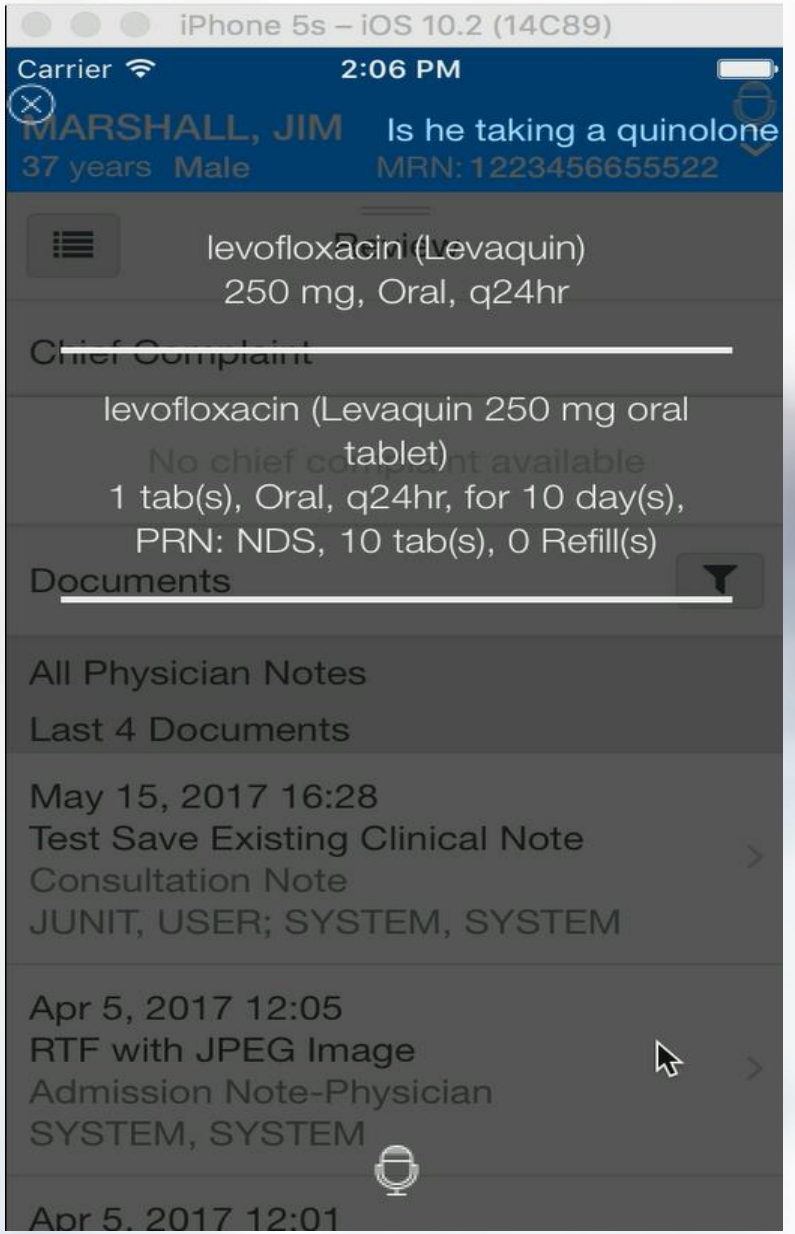
Clinical models

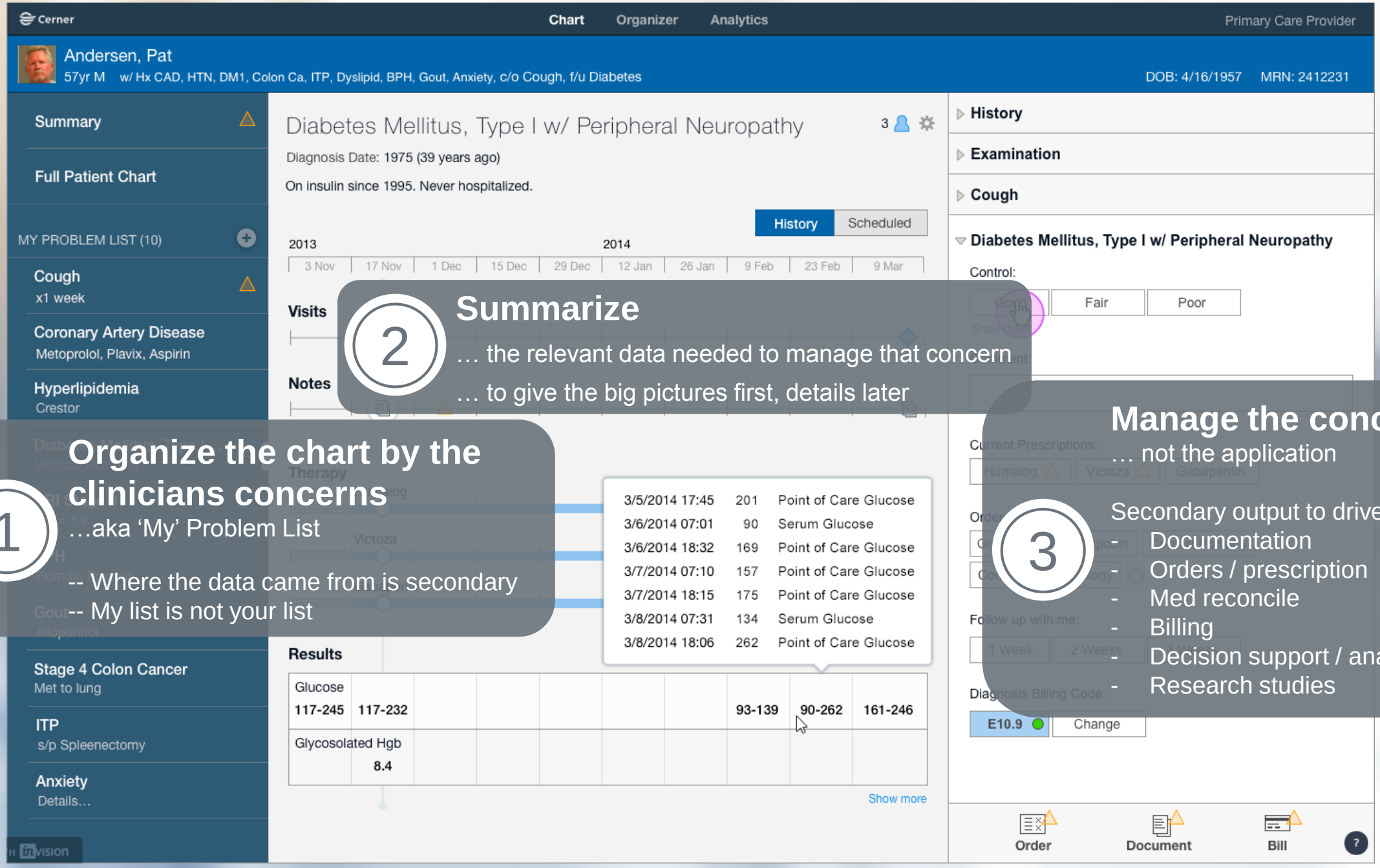
Prediction | Process

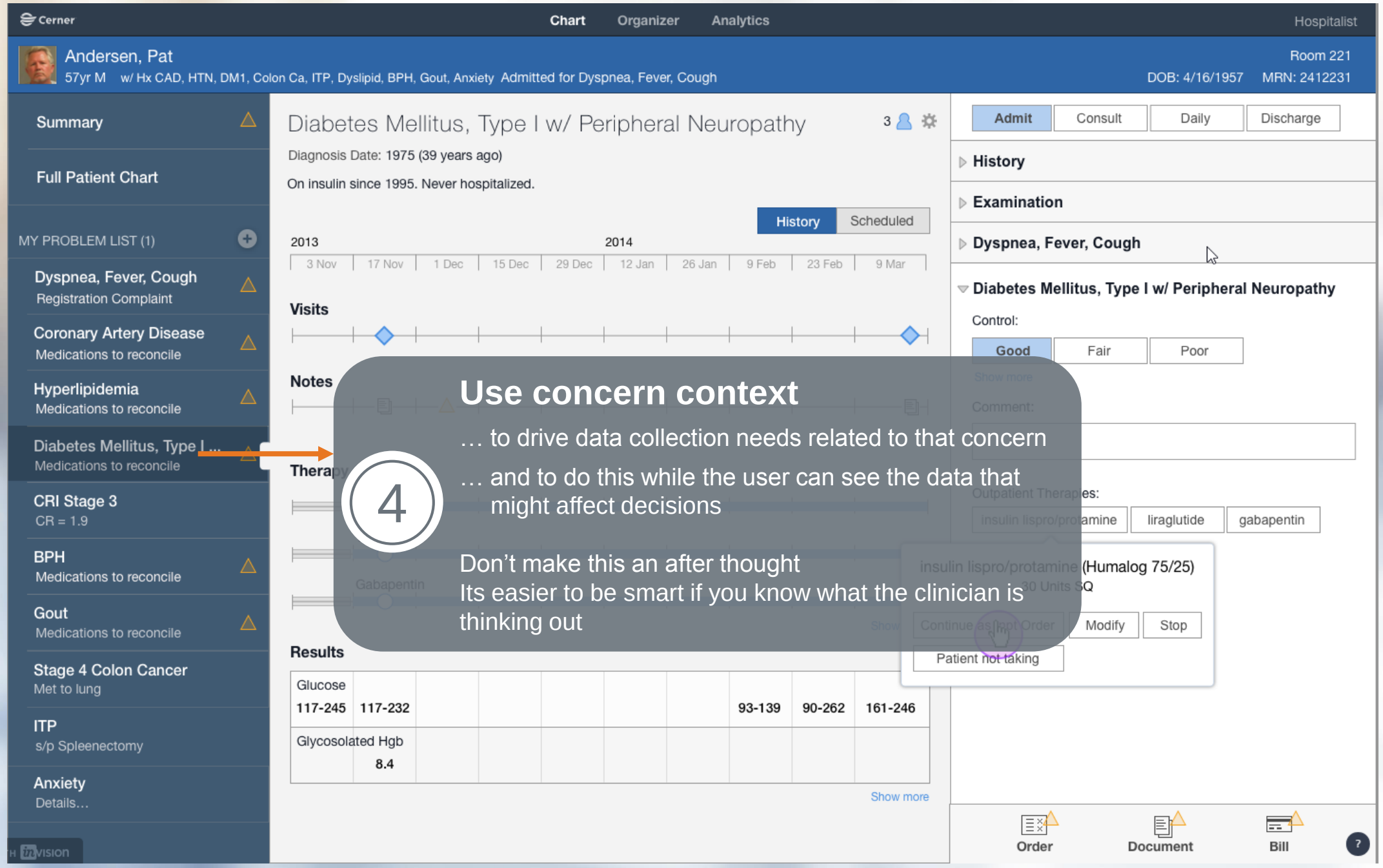
Speech-EHR integration

Interact with EHR using speech

- Speech recognition
- Intent analysis
- Concept mapping
- FHIR-based application integration




Cerner
Chart
Organizer
Analytics
Primary Care Provider
Andersen, Pat
57yr M w/ Hx CAD, HTN, DM1, Colon Ca, ITP, Dyslipid, BPH, Gout, Anxiety, c/o Cough, f/u Diabetes
DOB: 4/16/1957 MRN: 2412231
Summary
Full Patient Chart
MY PROBLEM LIST (10)
Cough
x1 week
Coronary Artery Disease
Metoprolol, Plavix, Aspirin
Hyperlipidemia
Crestor
Stage 4 Colon Cancer
Met to lung
ITP
s/p Spleenectomy
Anxiety
Details...
Diabetes Mellitus, Type I w/ Peripheral Neuropathy
Diagnosis Date: 1975 (39 years ago)
On insulin since 1995. Never hospitalized.
History
Scheduled
2013
2014
3 Nov
17 Nov
1 Dec
15 Dec
29 Dec
12 Jan
26 Jan
9 Feb
23 Feb
9 Mar
Visits
Notes
Therapy
Victoza
Allopurinol
3/5/2014 17:45 201 Point of Care Glucose
3/6/2014 07:01 90 Serum Glucose
3/6/2014 18:32 169 Point of Care Glucose
3/7/2014 07:10 157 Point of Care Glucose
3/7/2014 18:15 175 Point of Care Glucose
3/8/2014 07:31 134 Serum Glucose
3/8/2014 18:06 262 Point of Care Glucose
Results
Glucose
117-245 117-232 93-139 90-262 161-246
Glycosolated Hgb
8.4
Show more
History
Examination
Cough
Diabetes Mellitus, Type I w/ Peripheral Neuropathy
Control:
Fair
Poor
Current Prescriptions:
Humalog
Victoza
Gabapentin
Follow up with me:
1 Week
2 Weeks
Diagnosis Billing Code:
E10.9
Change
Order
Document
Bill
2
Summarize
… the relevant data needed to manage that concern
… to give the big pictures first, details later
1
Organize the chart by the clinicians concerns
…aka 'My' Problem List
-- Where the data came from is secondary
-- My list is not your list
3
Manage the concern
… not the application
Secondary output to drive:
- Documentation
- Orders / prescription
- Med reconcile
- Billing
- Decision support / analytics
- Research studies


Cerner
Chart
Organizer
Analytics
Hospitalist
Andersen, Pat
57yr M w/ Hx CAD, HTN, DM1, Colon Ca, ITP, Dyslipid, BPH, Gout, Anxiety Admitted for Dyspnea, Fever, Cough
Room 221
DOB: 4/16/1957 MRN: 2412231
Summary
Full Patient Chart
MY PROBLEM LIST (1)
Dyspnea, Fever, Cough
Registration Complaint
Coronary Artery Disease
Medications to reconcile
Hyperlipidemia
Medications to reconcile
Diabetes Mellitus, Type I ...
Medications to reconcile
CRI Stage 3
CR = 1.9
BPH
Medications to reconcile
Gout
Medications to reconcile
Stage 4 Colon Cancer
Met to lung
ITP
s/p Spleenectomy
Anxiety
Details...
Diabetes Mellitus, Type I w/ Peripheral Neuropathy
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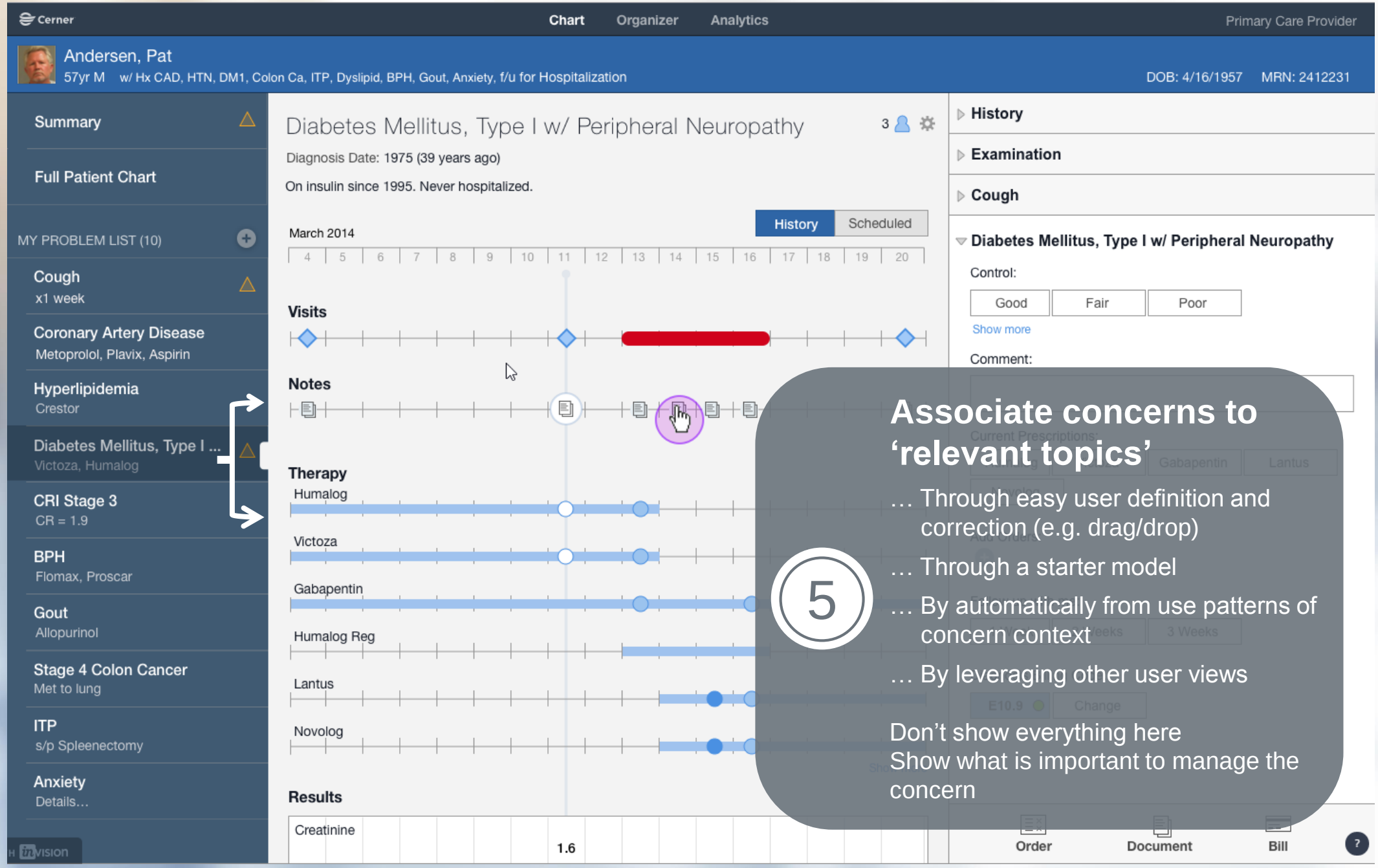
Therapy
Gabapentin
Results
Glucose
117-245
117-232
93-139
90-262
161-246
Glycosolated Hgb
8.4
Show more
Admit
Consult
Daily
Discharge
History
Examination
Dyspnea, Fever, Cough
Diabetes Mellitus, Type I w/ Peripheral Neuropathy
Control:
Good
Fair
Poor
Show more
Comment:
Outpatient Therapies:
insulin lispro/protamine
liraglutide
gabapentin
insulin lispro/protamine (Humalog 75/25)
30 Units SQ
Continue as Ord
Modify
Stop
Patient not taking
Order
Document
Bill
4
Use concern context
… to drive data collection needs related to that concern
… and to do this while the user can see the data that might affect decisions
Don't make this an after thought
Its easier to be smart if you know what the clinician is thinking out



5

Associate concerns to ‘relevant topics’

… Through easy user definition and correction (e.g. drag/drop)

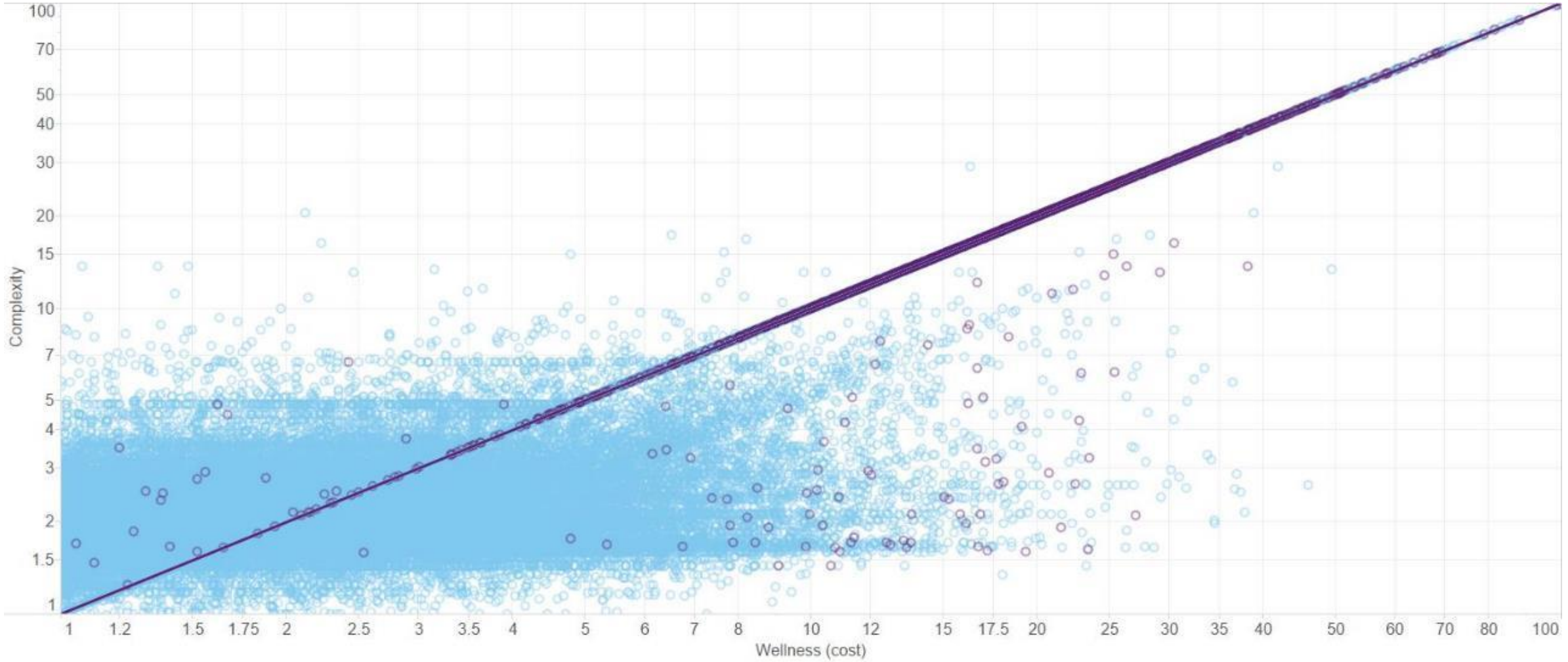
… Through a starter model

… By automatically from use patterns of concern context

… By leveraging other user views

Don’t show everything here
Show what is important to manage the concern

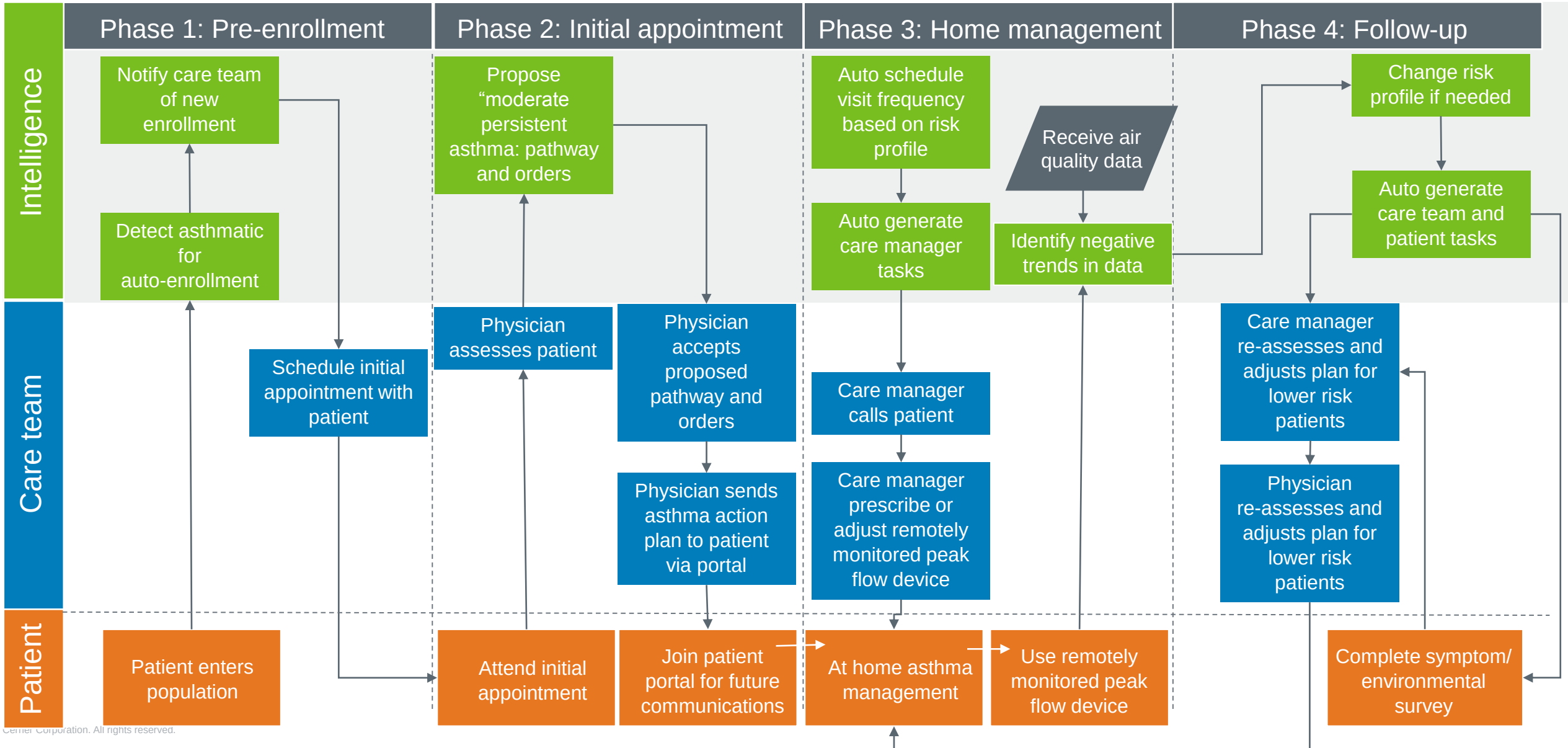
Population health spectrum: super utilizers



Re-classification of discharge locations

Discharge locations	Actual (historic)	Model recommendations		Model
		Higher level	Lower level	
Home	67.1%	11%	19%	66.4% ↓
Home health	13.2%			15.5% ↑
Skilled nursing facility	14.7%			14.2% ↓
Rehab	2.4%			1.6% ↓
Long-term acute care	2.6%			2.3% ↓

Dynamic plan for asthma



Blockchain

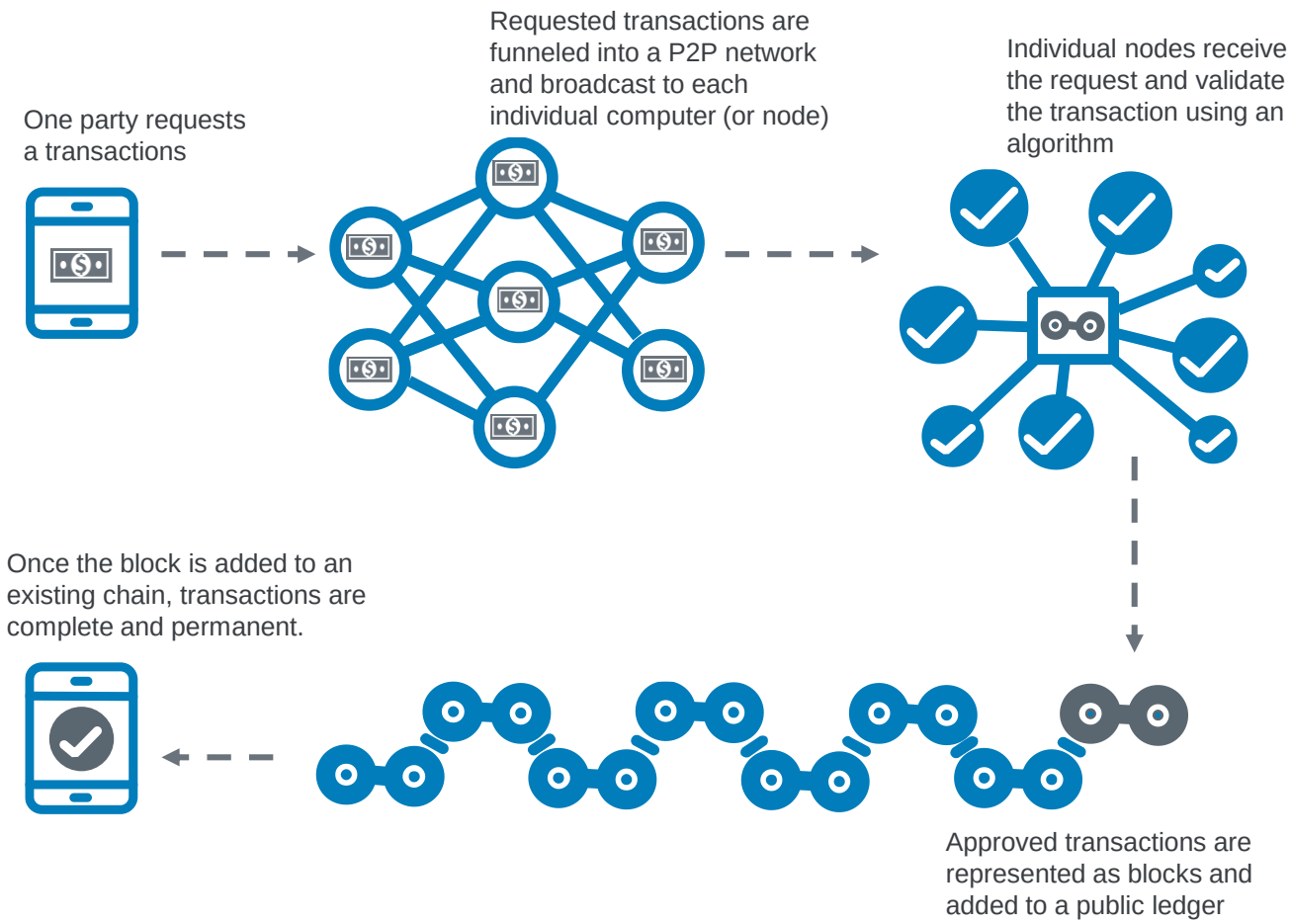
How does blockchain work?

Blockchain is a novel form of bookkeeping and transaction tracking; it serves as the foundation of cryptocurrencies like Bitcoin.

This coding breakthrough—which consists of concatenated blocks of transactions—allows competitors to share a digital ledger across a network of computers without need for a central authority.

No single party has the power to tamper with the records: the math keeps everyone honest.

Blockchain may be useful in situations where trust is important and/or there are inefficiencies introduced by transaction intermediaries.



Source: Fortune/G2 Crowd

Proof of stake algorithm

Protocol π_{DPOS}

π_{DPOS} is a protocol run by stakeholders $U_1, \ldots, U_n$ interacting among themselves and with $\mathcal{F}_{\mathcal{LS}}^{D,\mathsf{F}}$ over a sequence of L slots $S = \{sl_1, \ldots, sl_L\}$. π_{DPOS} proceeds as follows:

1. **Initialization** When π_{SPOS} starts, each stakeholder $U_i \in \{U_1, \ldots, U_n\}$ sends $(\mathsf{genblock\_req}, U_i)$ to $\mathcal{F}_{\mathcal{LS}}^{D,\mathsf{F}}$, receiving $(\mathsf{genblock}, B_0, \mathsf{F})$ as answer. U_i sets an internal blockchain $C = B_0$ and a initial internal state $st = H(B_0)$.
2. **Chain Extension** For every slot $sl_j \in S$, every online stakeholder U_i performs the following steps:
   (a) If a new epoch e_k has started, U_i sends $(\mathsf{genblock\_req}, U_i, e_j)$ to $\mathcal{F}_{\mathcal{LS}}^{D,\mathsf{F}}$, receiving $(\mathsf{genblock}, B_0^j, \mathsf{F})$ as answer. U_i extends its internal blockchain with B_0^j and sets it as the new epoch's genesis block, storing ρ^{k-1} and parameterizing the leader selection function F with ρ^k contained in the new B_0^k. If more than one epoch has passed, U_i repeats this procedure for each new epoch.
   (b) Collect all valid chains received via broadcast into a set $\mathbb{C}$, verifying that for every chain $C' \in \mathbb{C}$ and every block $B' = (st', d', sl', \sigma') \in C'$ it holds that $\mathsf{Vrf}_{\mathsf{vk}'}(\sigma', (st', d', sl')) = 1$, where vk' is the verification key of the stakeholder $U' \leftarrow \mathsf{F}(\rho^k, sl')$ with F parameterized by ρ^k corresponding to the slot to which B' belongs (as determined by sl'). U_i calls the function $\mathsf{maxvalid}(C, \mathbb{C})$ to select a new internal chain $C \in \mathbb{C}$ and sets state $st = H(B_h)$, where $B_h = \text{head}(C)$.
   (c) If U_i is the slot leader determined by $\mathsf{F}(\rho^k, sl_j)$, it generates a new block $B = (st, d, sl_j, \sigma)$ where st is its current state, $d \in \{0,1\}^*$ is data and $\sigma = \mathsf{Sign}_{\mathsf{sk}_i}(st, d, sl_j)$ is a signature on (st, d, sl_j). U_i extends C by appending B, obtains $C = C|B$ and broadcasts the new C.

Blockchain use cases

Blockchain uses

- Registering the creation of new bitcoins and recording bitcoin transactions
- Recording land sales and registration; pilots in India, Russia and Sweden
- Creating contracts that are automatically executed when certain conditions are met
- Establishing bank accounts for people in under-developed countries; a project of the Gates Foundation
- Creating a decentralized library; the Alexandria Project

Potential blockchain uses in health care

- Recording production and distribution of medications and medical supplies
- Establishing a different approach to interoperability/patient data exchange
- Managing patient consents and results for clinical trials
- Managing health insurance transactions and documents; eligibility, referral, claim submission and processing
- Protecting the privacy of patient data

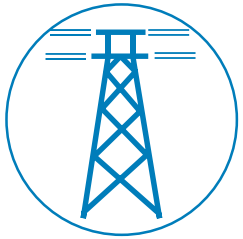
Is blockchain the answer to healthcare interoperability?

BRIEF

Blockchain shows promise in improving interoperability, IDC report says

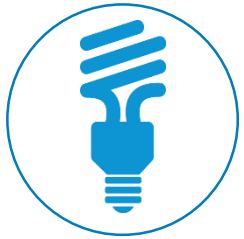
Internet of Things

IoT components



Things

(e.g., engines, humans, electricity grids, chemical production plants)



Sensors

(e.g., light, heat, position, chemical composition, temperature)

Processor and analytics on “the thing”

(e.g., mobile phone, embedded microprocessor)

Connectivity

(e.g., the Internet)

“Central” analytics

often cloud-based

(e.g., traffic flow, feedback on blood sugar control, predictive analysis of equipment component failure)

Examples of IoT use

Golf courses
Selective irrigation in dry zones to reduce the water resources required in the green.

Wine quality enhancing
Monitoring soil moisture and trunk diameter in vineyards to control the amount of sugar in grapes and grapevine health.

Animal tracking
Location and identification of animals grazing in open pastures or location in big stables.

Intelligent shopping applications
Advices in the point of sale by customer habits, preferences, presence of allergic components for them or expiring dates

Waste management
Detection of rubbish levels in containers to optimize the trash collection routes.

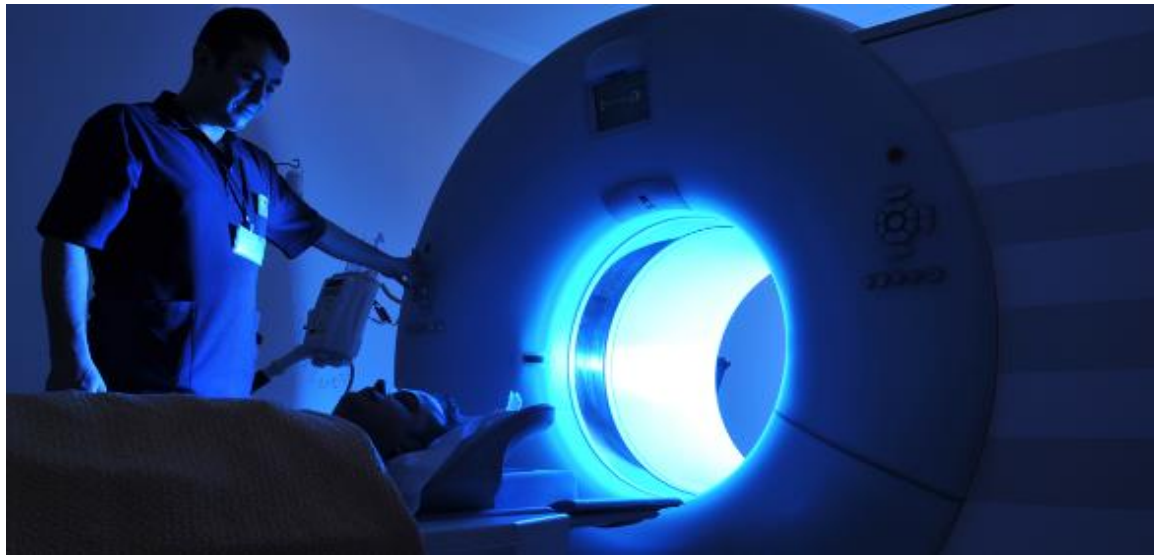
Smart parking
Monitoring of parking spaces availability in the city.

Smart roads
Intelligent highways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.

Categories of health care use cases

Equipment maintenance and performance optimization

- Identification of near term component failure
- Analysis of utilization
- Assessment of configuration
- Improved online support and trouble shooting



Categories of health care use cases

Supply management

- Real time notification of restocking and location of inventory needs
- Identification of supplies that have expired or been exposed to conditions that cause deterioration
- Analysis of supply utilization

Categories of health care use cases

Monitoring and management of public health status

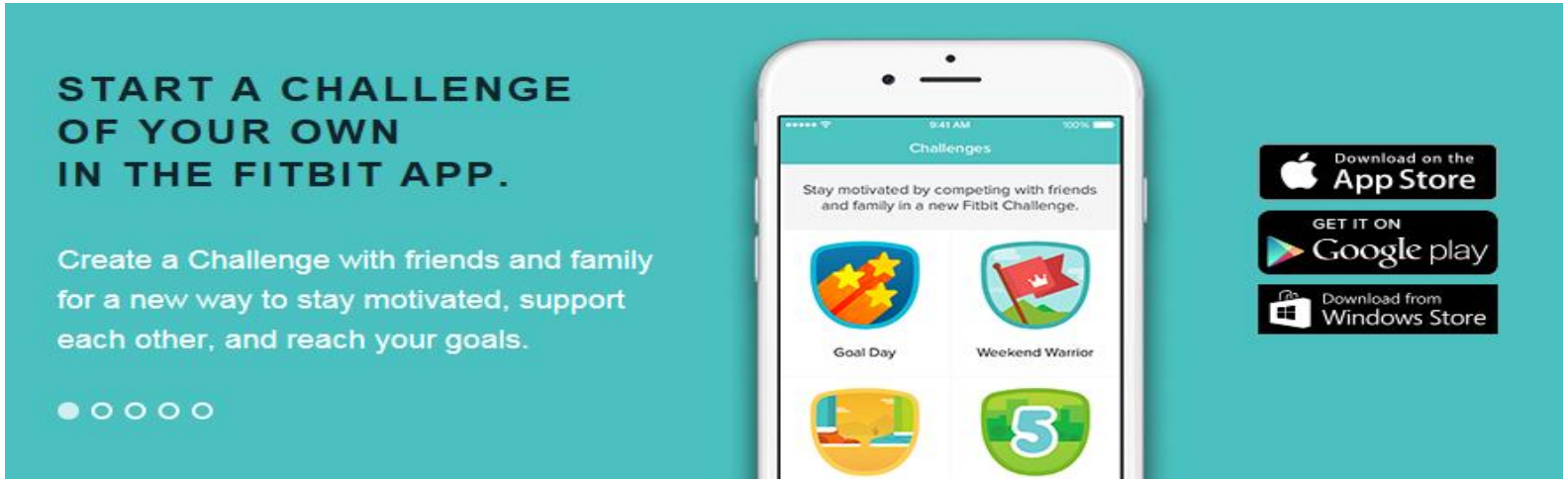
- Disease and bio-hazard surveillance
- Clinical trials data collection
- Environmental monitoring

Health forecast		
Air quality index (AQI)	**PM 2.5**	**Ozone**
Good	0 - 12.0 µg/m^3	0 – 0.059 ppm
Moderate	12.1 – 35.4 µg/m^3/td>	0.06 – 0.075 ppm
Unhealthy for sensitive groups	35.5 – 55.4 µg/m^3	0.076 – 0.095 ppm
Unhealthy	55.5 – 150.4 µg/m^3	0.096 – 0.115 ppm
Very unhealthy	150.5 – 210.4 µg/m^3	0.116 – 0.374 ppm
Hazardous	Above 210.5 µg/m^3	Above 0.379 ppm

Categories of health care use cases

Monitoring and management of patient health status

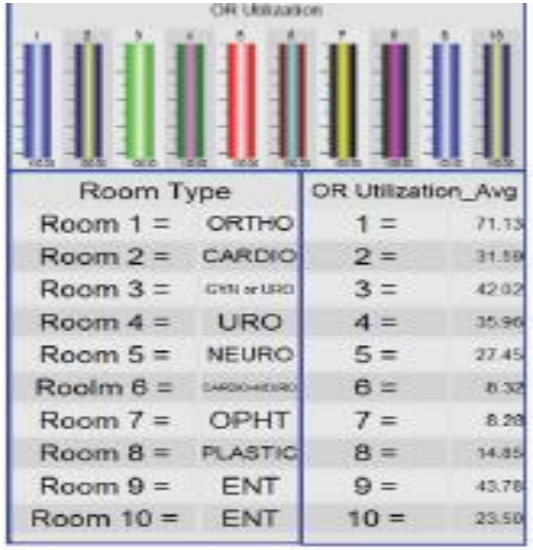
- Monitoring of physiological and health status with alerting of material condition change
- Monitoring of performance of implanted and external patient devices
- Feedback to guide/encourage desired health behaviors



Categories of health care use cases

Process optimization

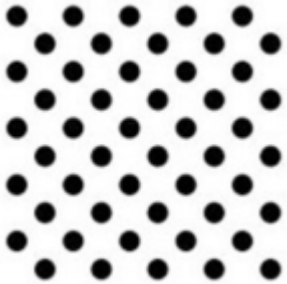
- Management of inpatient throughput through coordination of patients, providers, equipment and rooms
- Dynamic scheduling and locating of equipment based on utilization



Big data

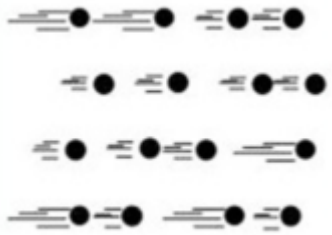
What makes data “big?”

Volume



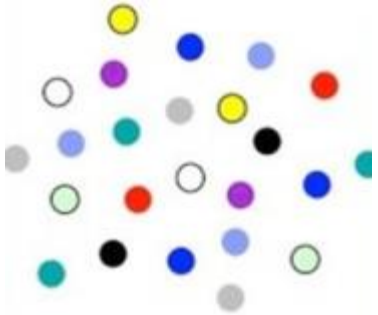
Terabytes to exabytes of existing data to process

Velocity



Streaming data, milliseconds to seconds to respond

Variety

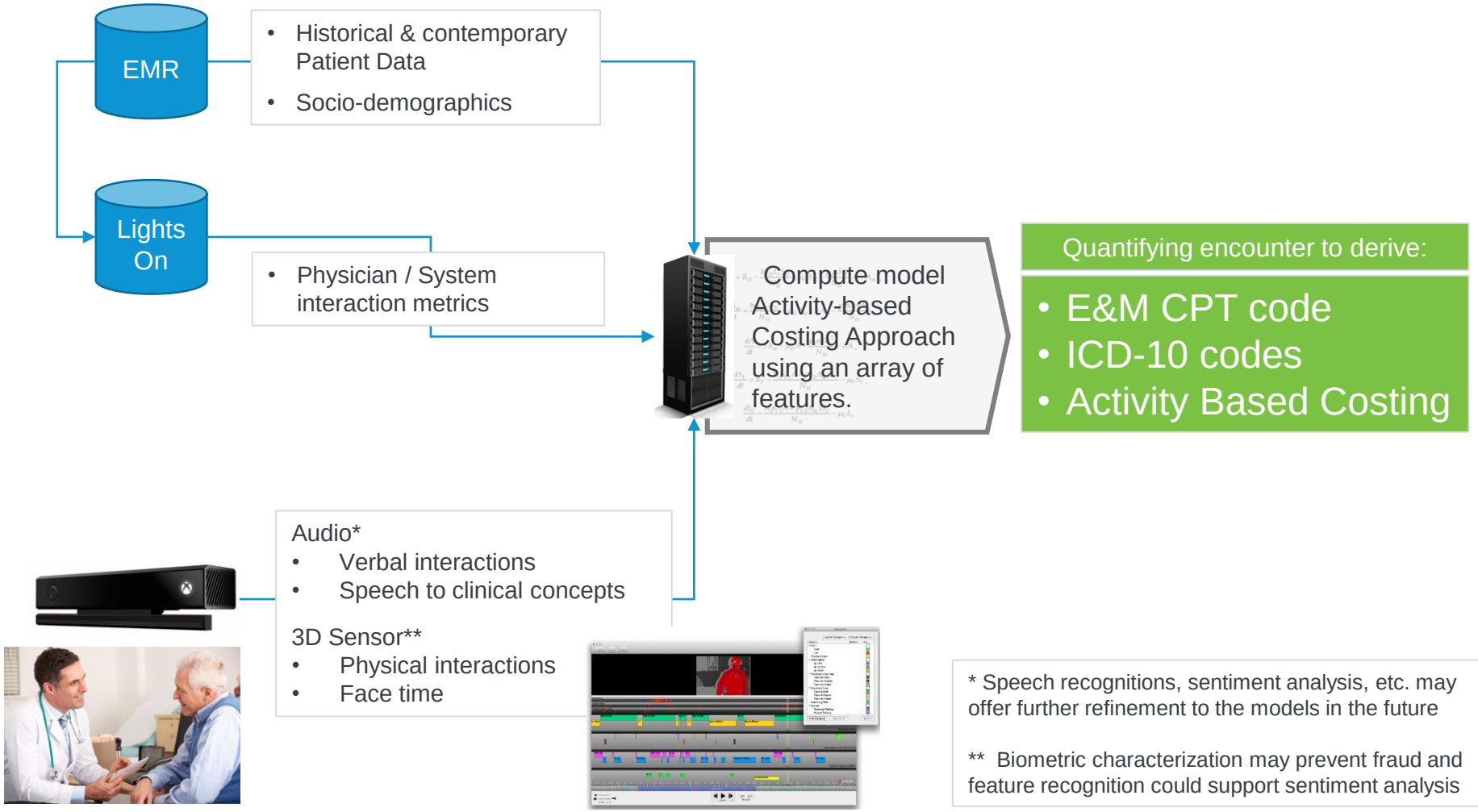


Structures, unstructured, text, multimedia

Veracity*

Uncertainty due to data inconsistency and incompleteness, ambiguities, latency, deception, model approximation

Observing the encounter

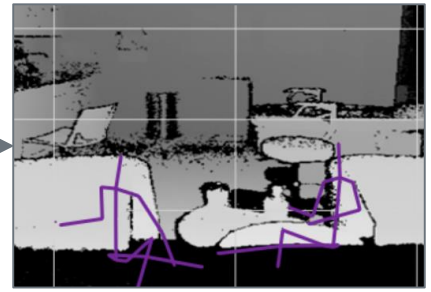


Exam room sensor data

In-room sensors

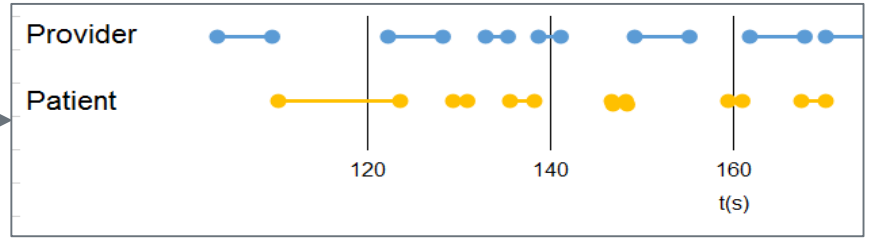
Outputs

1.a



3D visuals parsed out as stick figures with 23 ‘skeletal points’

1.b



Temporal audio data

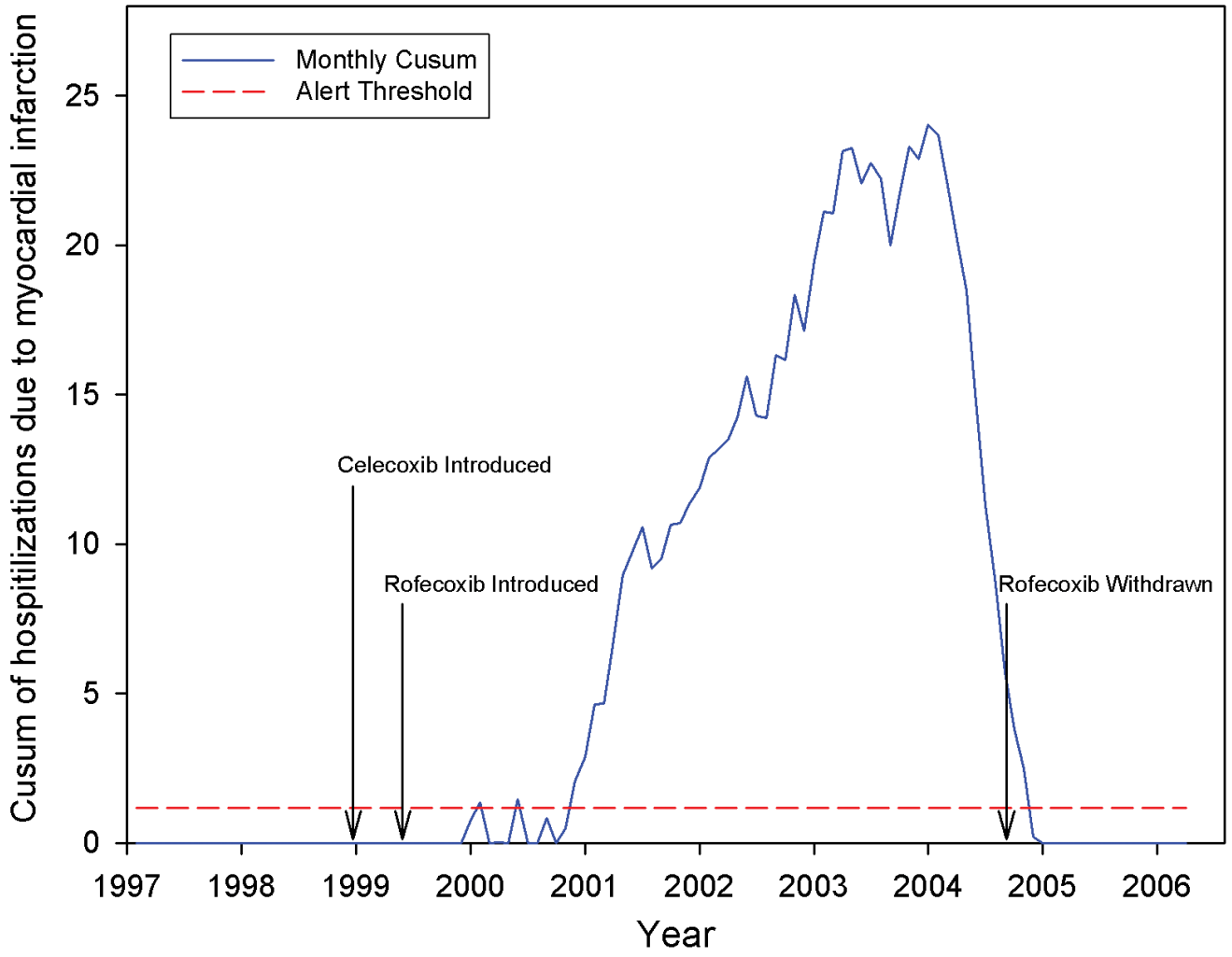
1.c

Dr: I see you've been having your cough for about 3 days now. Tell me more about it.

Patient: Well it rattles, I'm bringing up clear mucous and its keeping me awake at night. I've been short of breath and I just don't feel well.

Clinical concepts

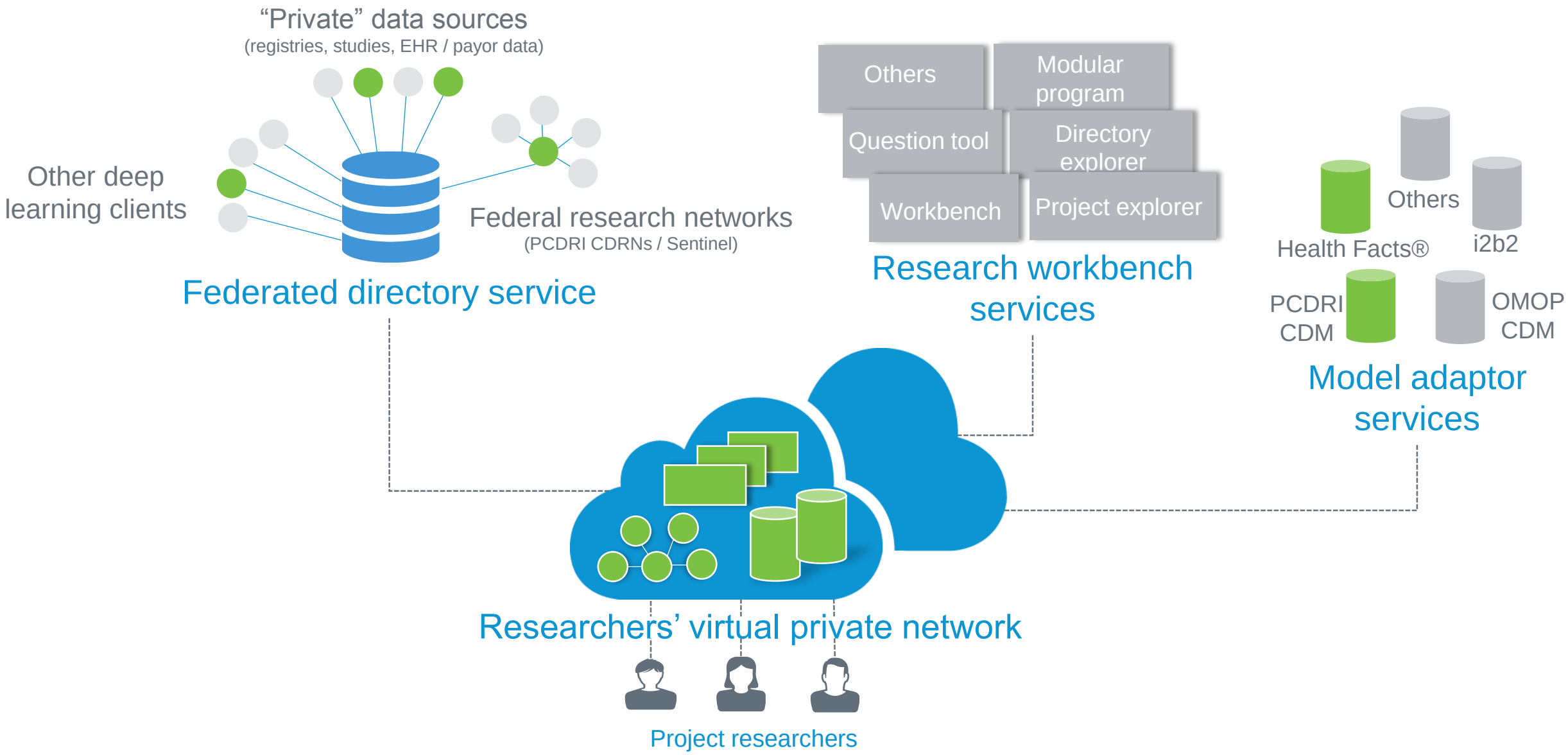
Vioxx's adverse effects through EHR data



Cumulative sum chart of monthly incidence of hospitalizations due to myocardial infarction from January 1, 1997 to March 30, 2006

Brownstein, PLoS ONE, 2007

Federated research and analysis using deep learning



Closing comments

Foundational perspectives of information technology

There is no such thing as a “killer app” or “killer technology”

There are “killer business models” and “killer process innovations” that are enabled by apps and technology

Major technology-enabled advances occur when:

People, process, technology and regulations change in concert

An ecosystem of technologies converge

Profound technology-enabled changes to an industry can take decades and be uneven

Questions