Machine Learning and Advanced Analytics

June 25, 2018

Agenda

- **Welcome**
  - **Claudia Ellison,** Director of Programs, eHealth Initiative
- **Discussion & Comments**
  - **William W. Feaster, MD, MBA**, Chief Health Information Officer, Children's Hospital of Orange County (CHOC)
  - **Marc Overhage, MD, PhD,** Vice President, Chief Medical Informatics Officer, Population Health, Cerner Corporation

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Housekeeping Issues

- All participants are muted
  - To ask a question or make a comment, please submit via the Q&A feature and we will address as many as possible after the presentations.
- Technical difficulties:
  - Use the chat box and we will respond as soon as possible
- Questions:
  - Use Q&A feature
- Today's slides will be available for download on eHI's Resource page **www.ehidc.org/resources**

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Our Mission

eHealth Initiative's mission is to serve as the industry leader convening executives from multi-stakeholder groups to identify best practices to transform healthcare through use of technology and innovation. eHI conducts, research, education and advocacy activities to support the transformation of healthcare.

Multi-stakeholder Leaders in Every Sector of Healthcare

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Convening Healthcare Executives

Research & Identify Best Practices

Best Practice Committees Identify & Disseminate Success Stories

Value & Reimbursement

Technology & Analytics

Workflow for Providers and Patients

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eHealth Resource Center Available With Best Practices & Findings

Best Practice Committees contribute to the eHealth Resource Center **www.ehidc.org/resources** which provides assistance, education and information to organizations transforming healthcare through the use of information, technology and innovation. The Resource Center is a compilation of reports, presentations, survey results, best practices and case studies from the last 16 years.

This webinar was made possible through the generosity and support of

eHEALTH INITIATIVE

Speakers

William W. Feaster, MD, MBA
Chief Health Information Officer, Children's Hospital of Orange County (CHOC)

Marc Overhage, MD, PhD
Vice President, Chief Medical Informatics Officer, Population Health, Cerner Corporation

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Intelligence meets longitudinal plan

Automating creation and management of activities in a longitudinal plan

Marc Overhage, MD, PhD, FACMI, FNAM, MACP, Cerner
William W. Feaster, MD, CHIO, CHOC Children's Hospital

CHOC Children's

Cerner

Cerner

Types of care plans

Longitudinal care plan

- A comprehensive plan to achieve health-promoting goals and objectives. Specific goals regarding clinical, behavioral, and/or functional status are often included, and are measured via serial assessments over time. Longer term; care management over time.

Transitional care plan

- Identifies post-hospital needs, patient priorities, and readmission risks and the plan to address those needs, priorities and mitigate risks in the 30 days post discharge. Focus on ensure linkage to providers and services within the 30 day transitional period.

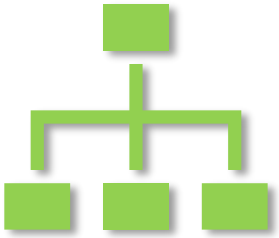
ED care plan

- Summary information for the ED provider to inform safe, effective, and consistent care in the ED and facilitate discharge with team-based follow up, as appropriate.

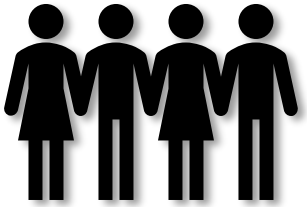
Acute care plan

- Details the activities and goals associated with care during a specific episode. This plan is usually targeted at a relatively narrow set of health concerns or problems.

Longitudinal care plans are…



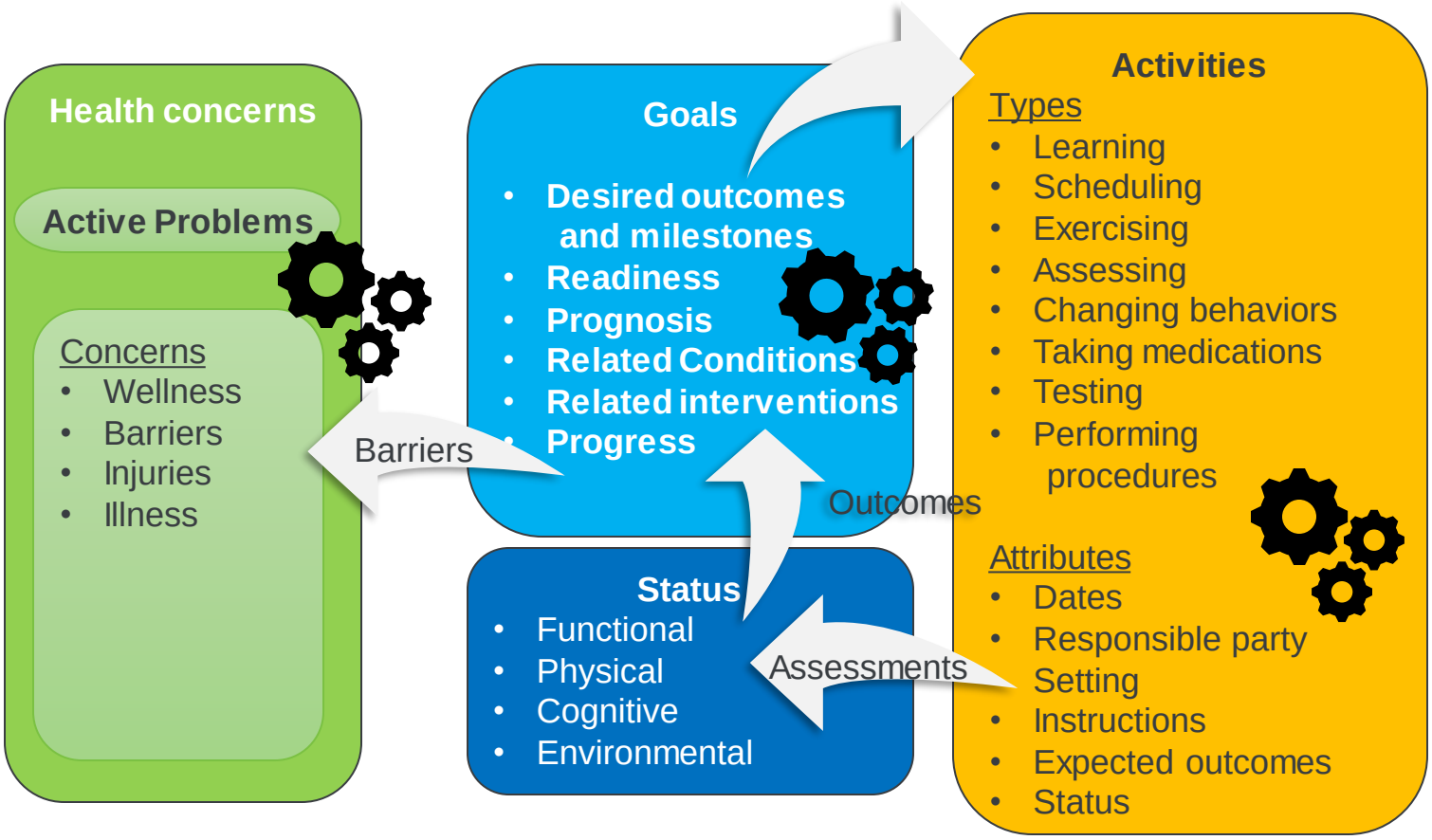
A synthesis of all “plans of care”



Driven by the entire care team

Ongoing and evolving

Care plan intelligence



Longitudinal care planning across an enterprise

Health Journey	PCP Millennium	Prescription Refills	Hospital	Rehab	Specialist Non-Mill
Evolving Goals	Keep Playing Basketball, exercise and visit with kids	New Medications	Review Longitudinal Plan Use Elements Pertaining to Acute Episode	Regain Ability to Stand and Walk	Feeling Tired Need to See A Doctor
Continuous Care Planning with Continuous Change	Reconcile Problems Add Goals Modify Medications Referral to Specialist Review Update Longitudinal Care Plan (OnePlan)	Forgot To Get a Refill Scripted Filled	Episodic Plan Reconcile and Update Longitudinal Plan Admit/Discharge	Review of Episodic Event Review Update Longitudinal Care Plan (OnePlan)	New Problems Added Medication Change Referral Received and Confirmed
Data Capture	Millennium Interaction Cloud Storage	Claims and Fill History	Millennium Entered and Stored	OnePlan Smart App or Millennium,	Interaction With Smart App, Healthe Record, CommonWell

Continuous updates to Longitudinal Plan

Update Plan on discharge

Healthcare has embraced intelligence for years

Decision support that critiques orders

Documentation tailored to a patient's condition

Care process models that guide workflow and care processes

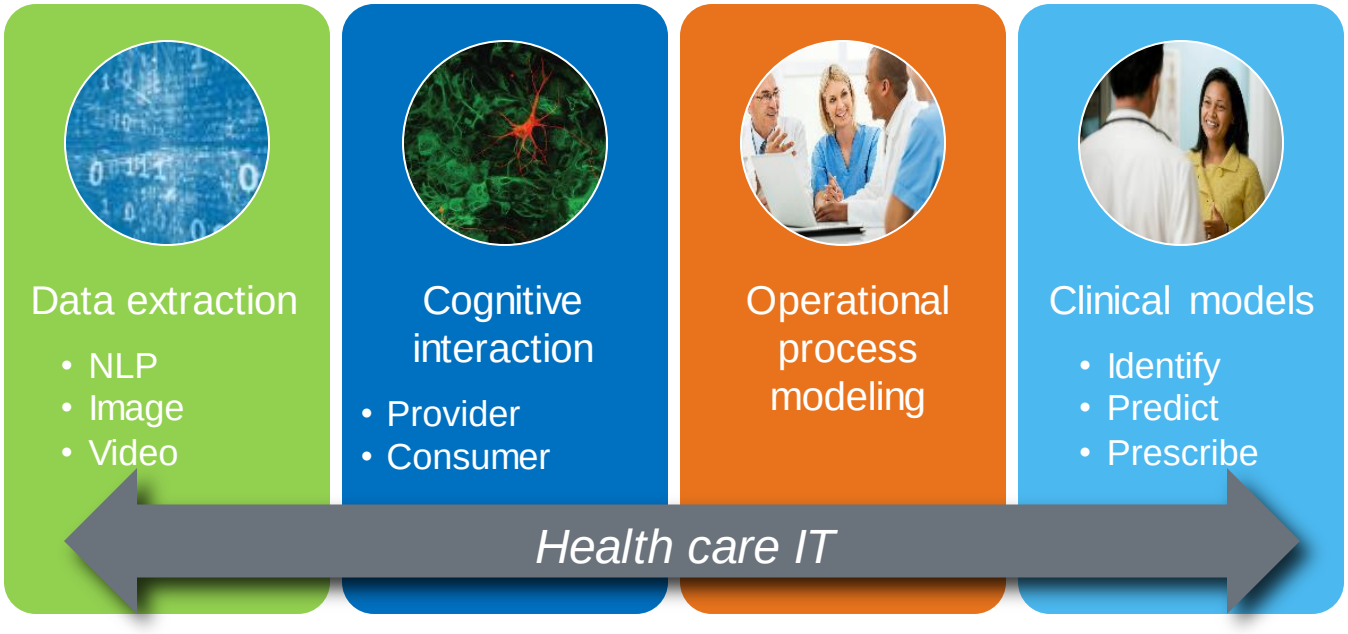
Surveillance that detects critical situations
e.g., sepsis

Predictive models
e.g., readmission risk

Logic that stratifies populations into meaningful cohorts

Analytics that enable organizations to measure cost and quality

The next generation of intelligence



Virtually assisting the care team

HealthePrograms

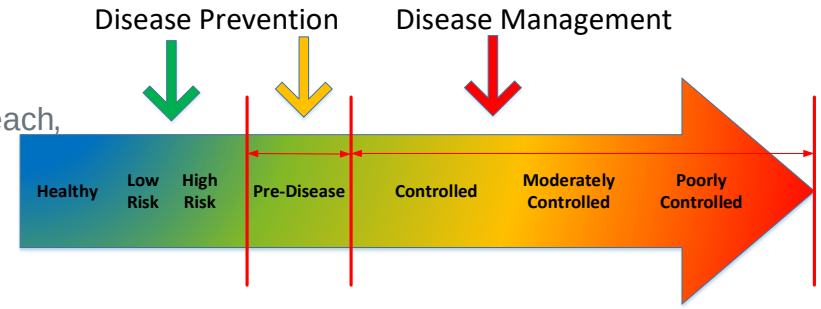
Identify, stratify, and engage individuals throughout the care continuum

Rationale:

- Managing the care of populations pose unique challenges for providers and patients

How it works:

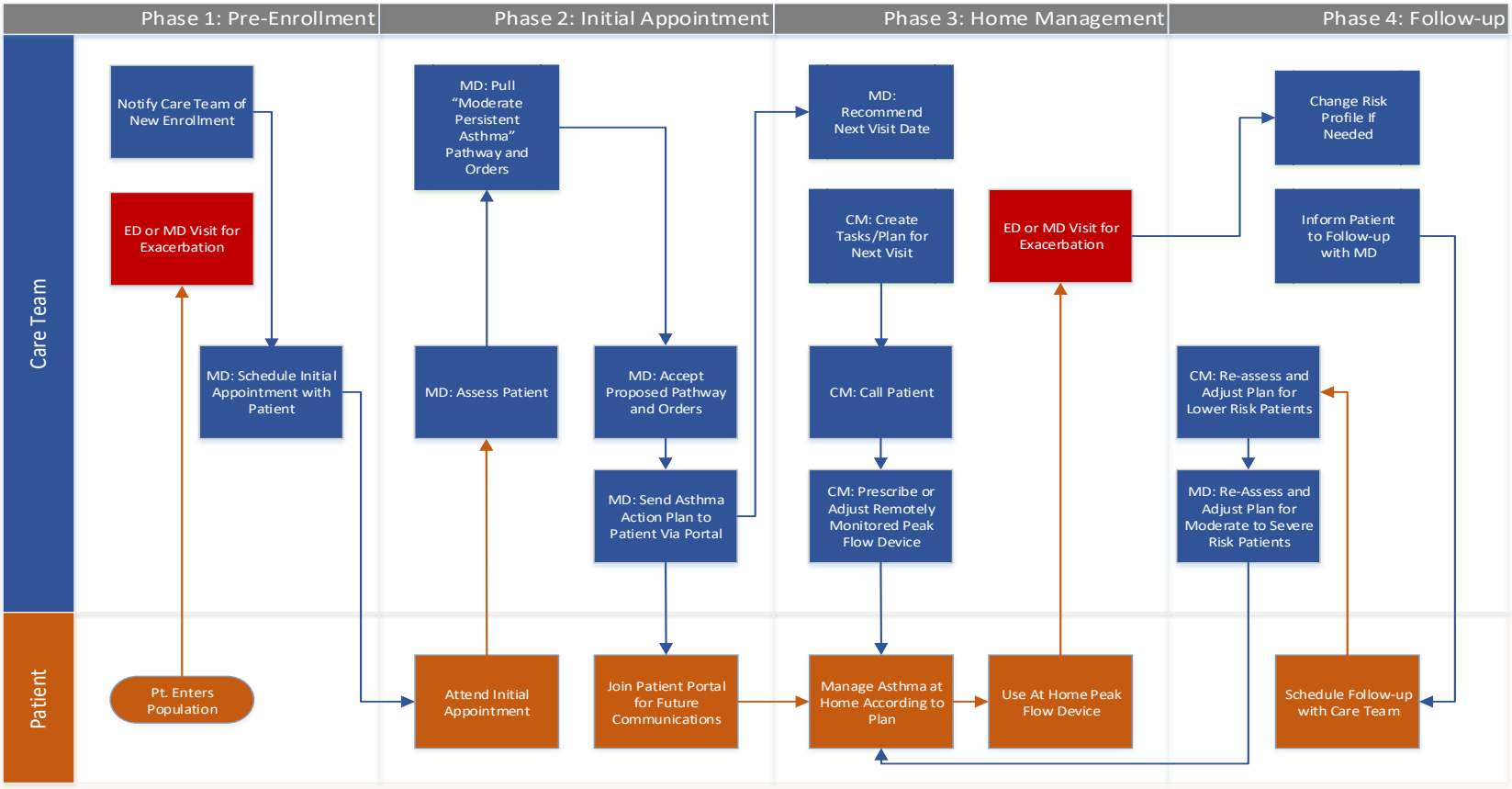
- Rule-based algorithms identify individuals with chronic conditions who need escalated care
- Once established, the care management process of outreach, intervention, and follow-up is algorithmically controlled
- Creates virtual assistant for the care team and patient



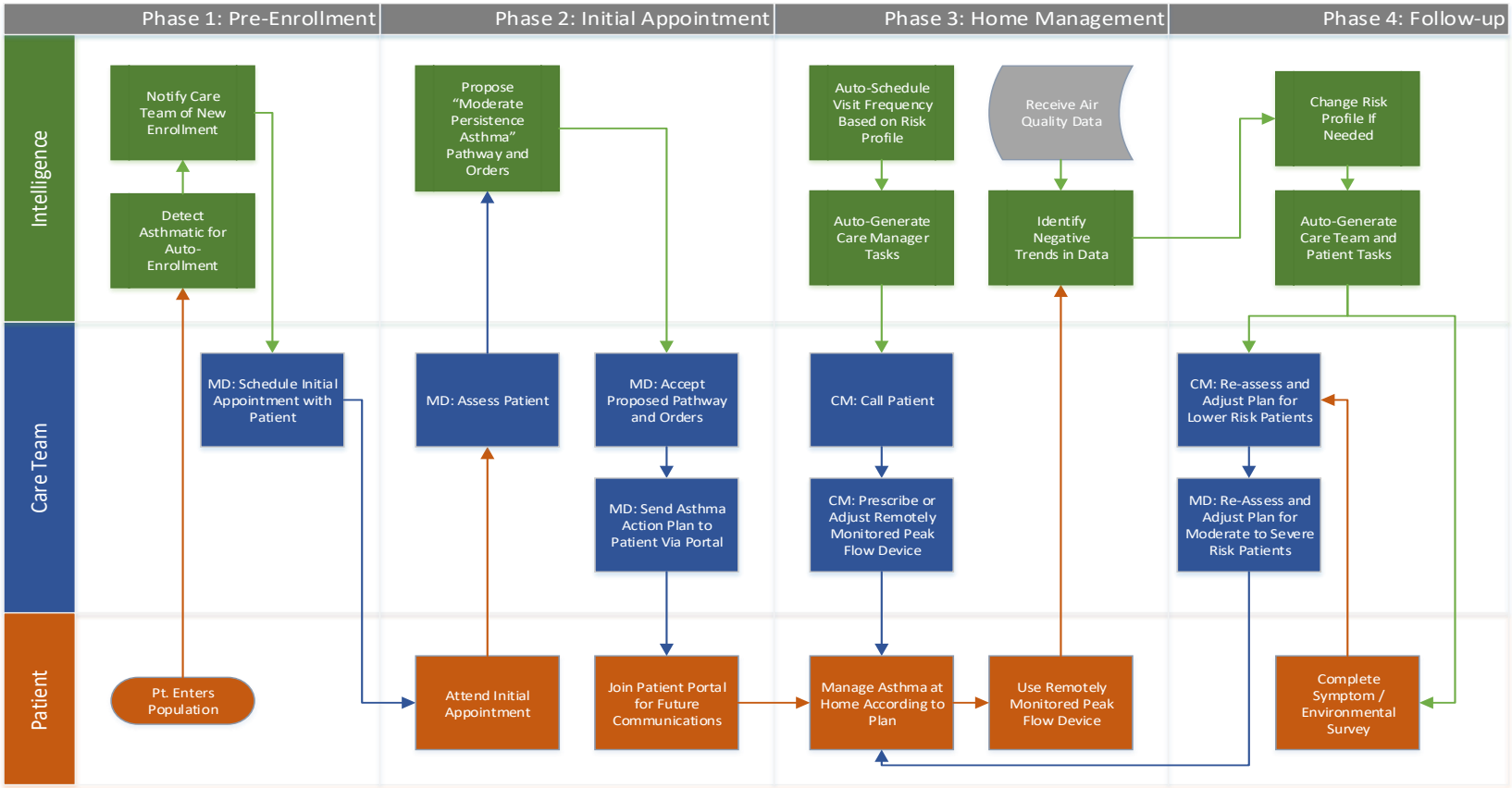
Current state:

- Live and testing at **one client**
- Pediatric programs under development with **a second large pediatric hospital system**

Disease management program



Program with embedded intelligence

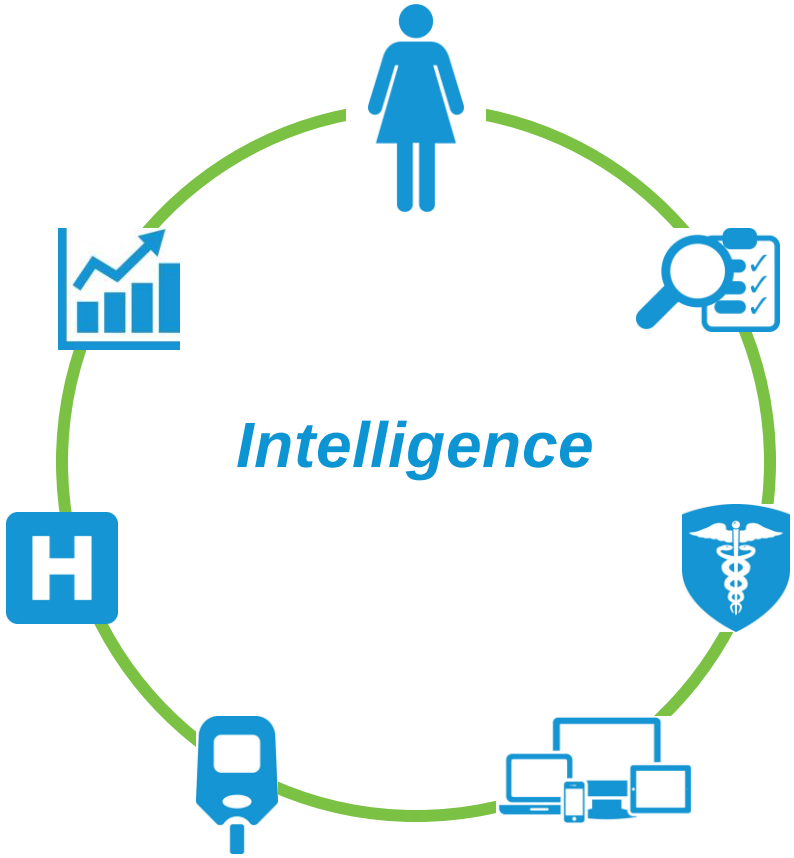


Example of a virtual assistant

Ambulatory population health management for patients with high impact chronic conditions

- **Goals**
  - Address gaps in care with gap-in-care identification rules
  - Emphasis on high-impact chronic conditions
- **Examples of rules**
  - Missing exercise program
  - Missing home blood pressure monitoring
  - Missing indicator - K
  - Missing flu vaccine
  - Missing long-term controller med
  - Unscheduled appointment
- **Examples of actions**
  - Monitoring key indicators
  - Adherence with treatment plan
  - Adherence with visits

- **6 high impact conditions**
  - Asthma
  - Emphysema / COPD
  - CHF
  - DM
  - Ischemic Heart Disease (IHD)
  - HTN



Member of the community

Diabetes Identification algorithm classifies person as *highly-suspected* of having diabetes

Visit Management algorithm recommends a screening with PCP

Communications and appointment details are sent to the Patient Portal (*HealtheLife)*

Person prescribed a **Remote Patient Monitoring** device to measure glucose levels at home

Results come back from PCP appointment and **Visit Management** algorithm recommends an appointment with Nephrologist

Device Surveillance algorithms continue to monitor person while away from clinic

Benefits of an integrated system

Data-driven modernized engagement

Improved patient recruitment, satisfaction & retention

Simplified outreach & referrals

Improved clinical & cost of care outcomes

Integrated patient / provider interactions

Improved business efficiencies & ROI

Valuable insight & data analytics

Improve patient recruitment, satisfaction & retention

- Segment your population, enable personalized engagement
- Market services and programs effectively
- Deliver the right content, at the right time, via the right method
- Foster loyalty with shared decision-making and participation

Simplify outreach & referrals

- Conduct patient portal sign-up campaigns
- Promote care management enrollment
- Recruit health plan members
- Send appointment reminders and change notifications
- Send automatic welcome emails

Improve clinical & cost of care outcomes

- Enable better personalization of preventive and medical care
- Close more gaps in care
- More proactive, frequent touch points
- Automate targeted interventions

Integrated patient / provider interactions

- Increase patient participation in care management protocols
- Support shared decision making among patients and providers
- Enhance patient experience and loyalty
- Boost provider experience and loyalty

Improve business efficiencies and ROI

- Save time and money by optimizing operational efficiency
- Connect consumer touchpoints across channels
- Improve customer experience, reduce patient churn and lower costs
- Capitalize on value and risk-based payment models

Valuable insight & data analytics

- Analyze impact at each patient interaction
- Facilitate A/B testing to optimize performance
- Personalize interaction based on profile and preferences
- Gain consumer engagement intelligence
- Identify how to improve health and care outcomes

Objectives of this presentation

We will explore how CHOC has:

- Leveraged EMR data to advance population health
- Applied data science to improve patient satisfaction and safety
- Begun the exploration of data with advanced artificial intelligence tools

William W. Feaster, MD
CHIO, CHOC Children's Hospital

CHOC
By the Numbers

343 Licensed tertiary care beds

- 82 Med/Surg
- 30 PICU
- 12 CVICU
- 72 NICU
- 18 Psychiatry
- 28 Hem/Onc
- 24 Neuro Science

CHOC @ MISSION HOSPITAL

54 Bed hospital within a hospital in South Orange Co

- 8 bed PICU
- 12 bed NICU
- Sleep Lab, Epilepsy Monitoring Unit

CLINICS

Fourteen Primary Care
Specialty Care Thirty

At-risk populations

I50,000 MediCal
50,000 Commercial

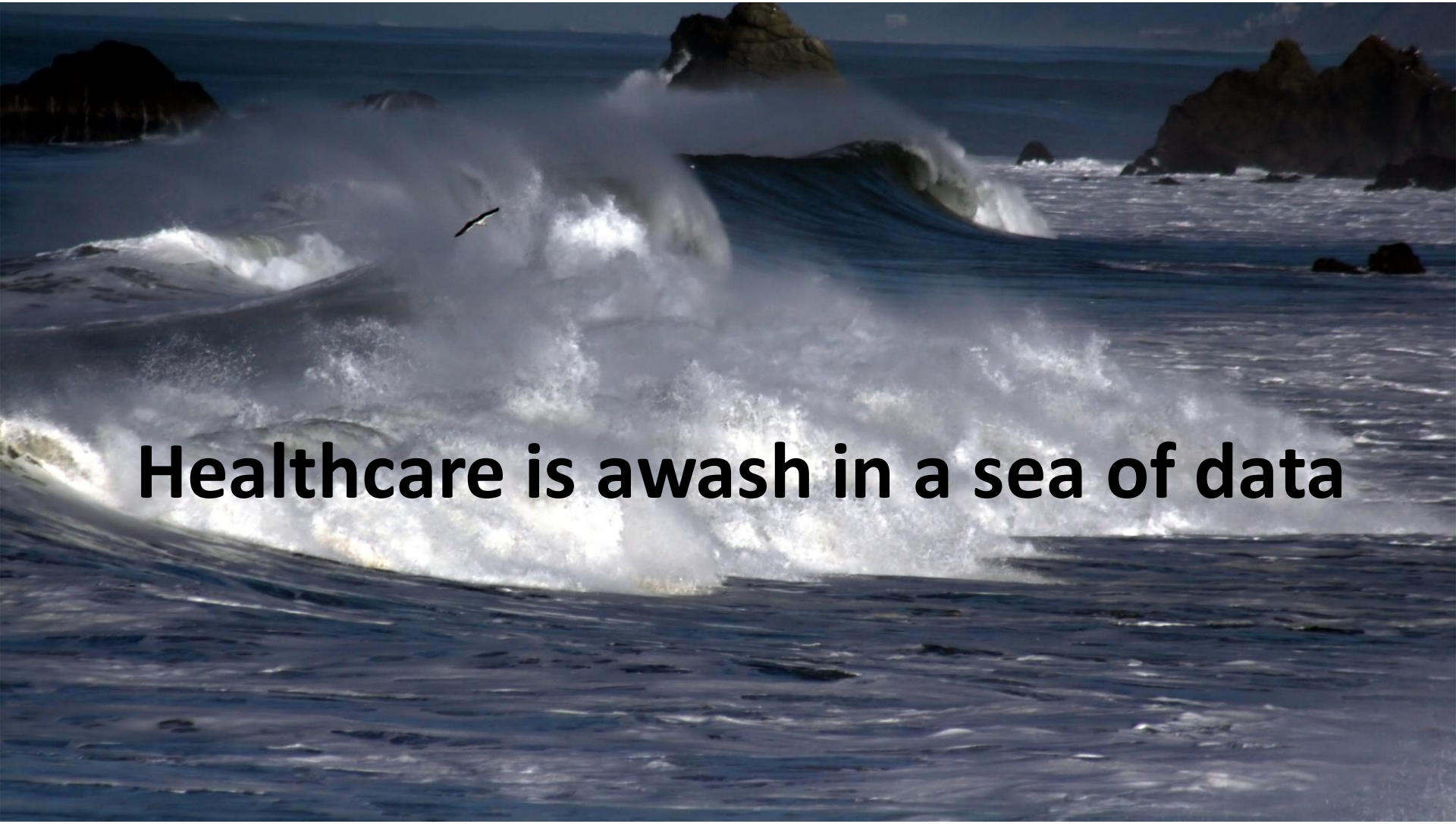
500 residents, fellows and med students – University of California – Irvine affiliation

THREE HUNDRED SEVENTY FIVE
active research STUDIES

FOCUS ON EXCELLENCE
AWARDS & GRANTS

Leapfrog Safe Hospital	Beacon Gold Level Award for Critical Care Excellence	Magnet Designation – Nursing Excellence	Gold Level CAPE (California Award Performance Excellence)	Ranked Nationally in Several Specialties	HIMSS EMR Adoption Model: Stage 7	CMS Transforming Clinical Practice Initiative Grant	Press Ganey Pinnacle of Excellence Award

Awarded the Nicholas E. Davies Award in 2016 for our work using our EHR to improve quality and patient safety


Healthcare is awash in a sea of data

We now have more access to data on whole populations of patients, not just those receiving hospital-based services

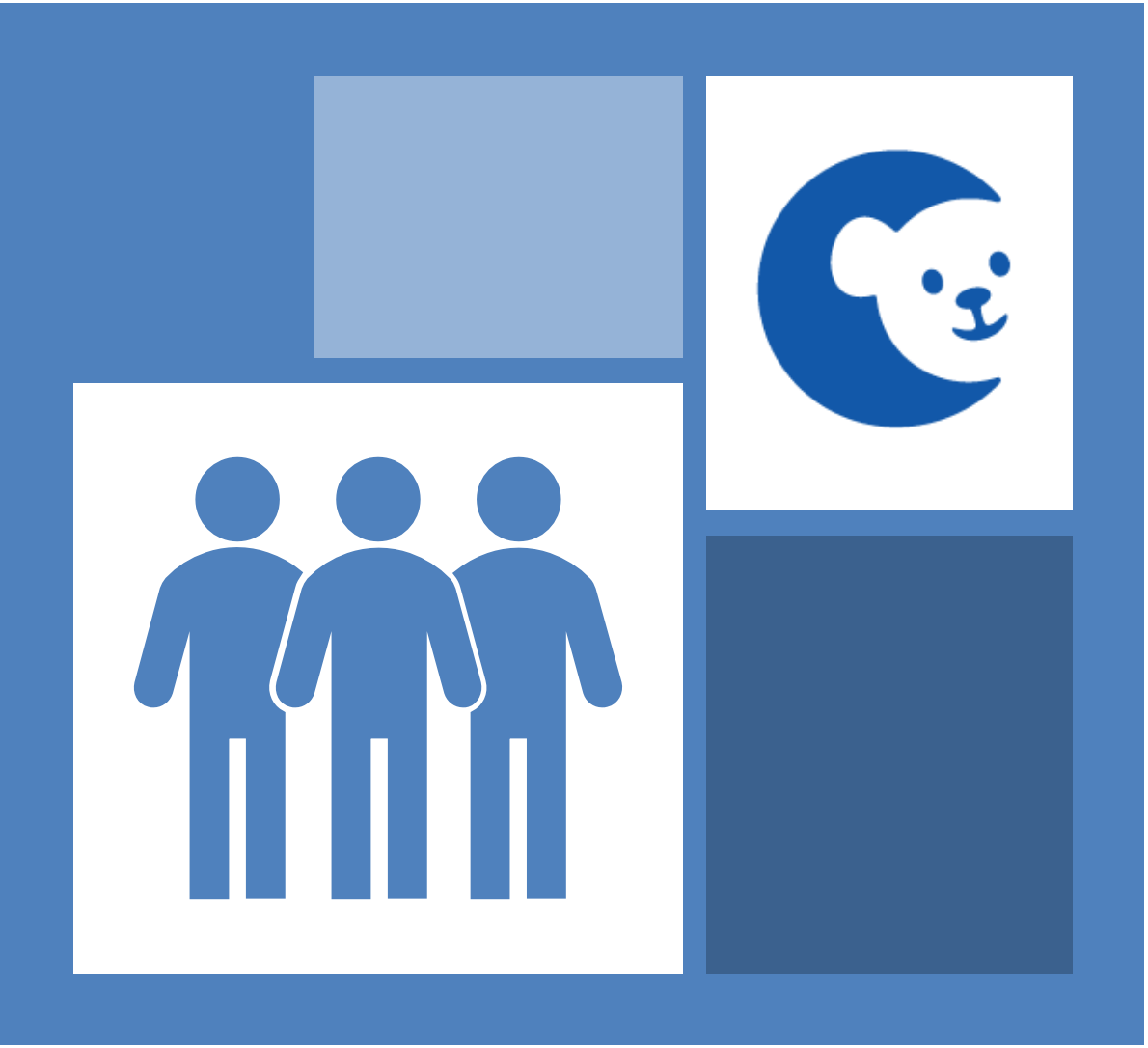
- Our instance of Cerner Millennium will soon have primary care data on over 300,000 patients in Orange County
- Our population health data warehouse now includes claims data from our IPA and multiple other data sources including eligibility, pharmacy and lab
- Soon, we will also be loading data on our patients from other facilities through our local HIE and all-payer practice data via 837 billing claims.

Compared to other industries, healthcare doesn't often take advantage of all this data

- A lot of our quality and registry reporting data is still obtained by manual chart abstraction
- We manage at-risk populations, but rely on 3-month old claims data to track care
- Patient satisfaction data is widely reported throughout the organization, but we often make assumptions on how to improve it
- Too often we rely only on our clinical judgement to determine readmission risk or detect patient deterioration

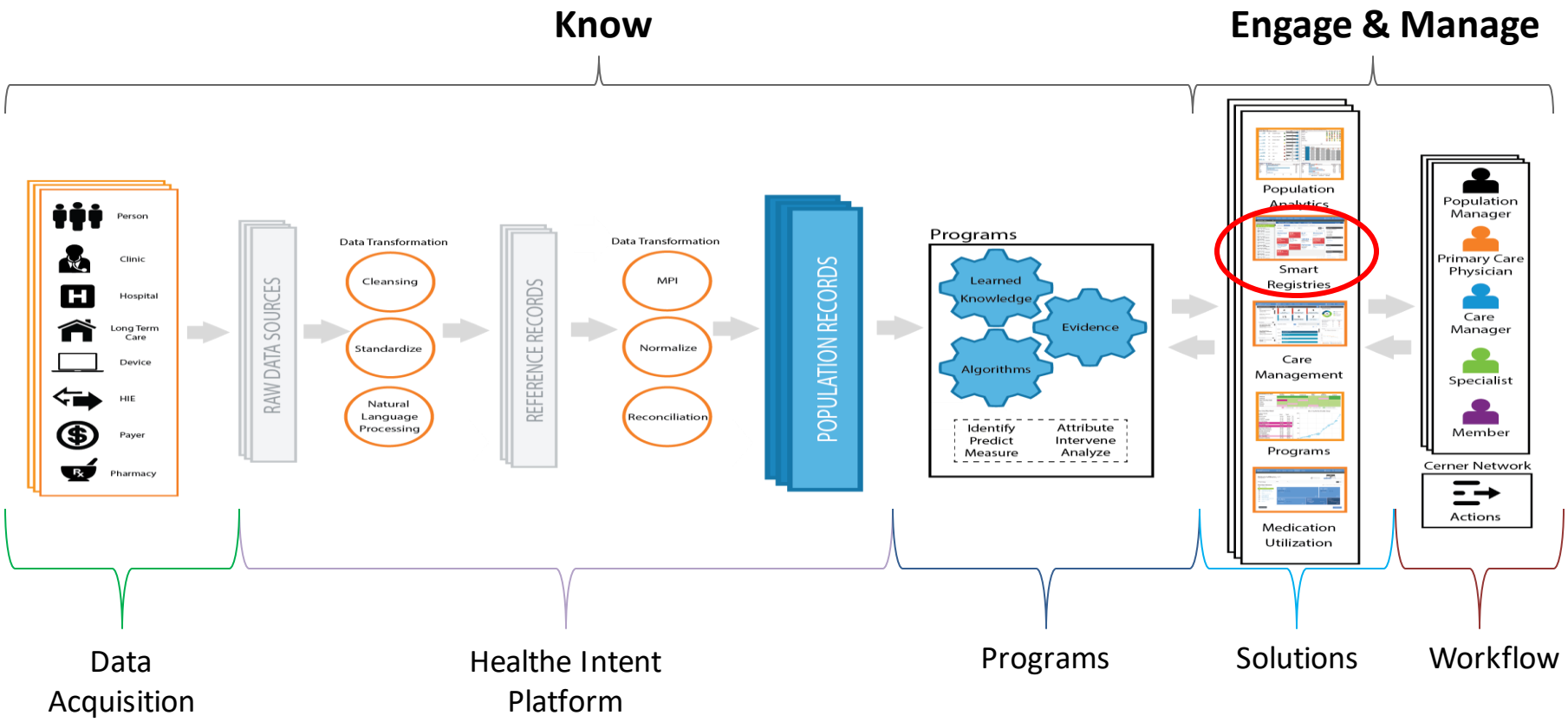
In God we trust. All others must bring ~~data~~. **Intelligence.**

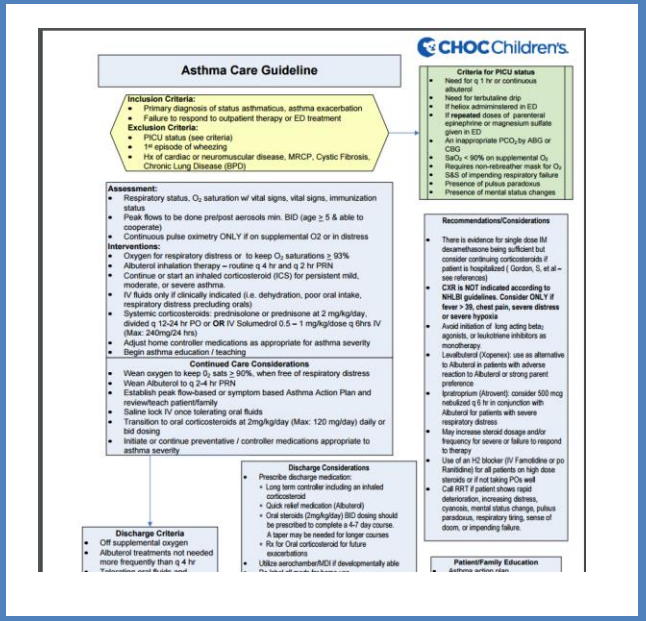
W. Edwards Deming



Leveraging Data to Advance Population Health

The *HealtheIntent*® platform



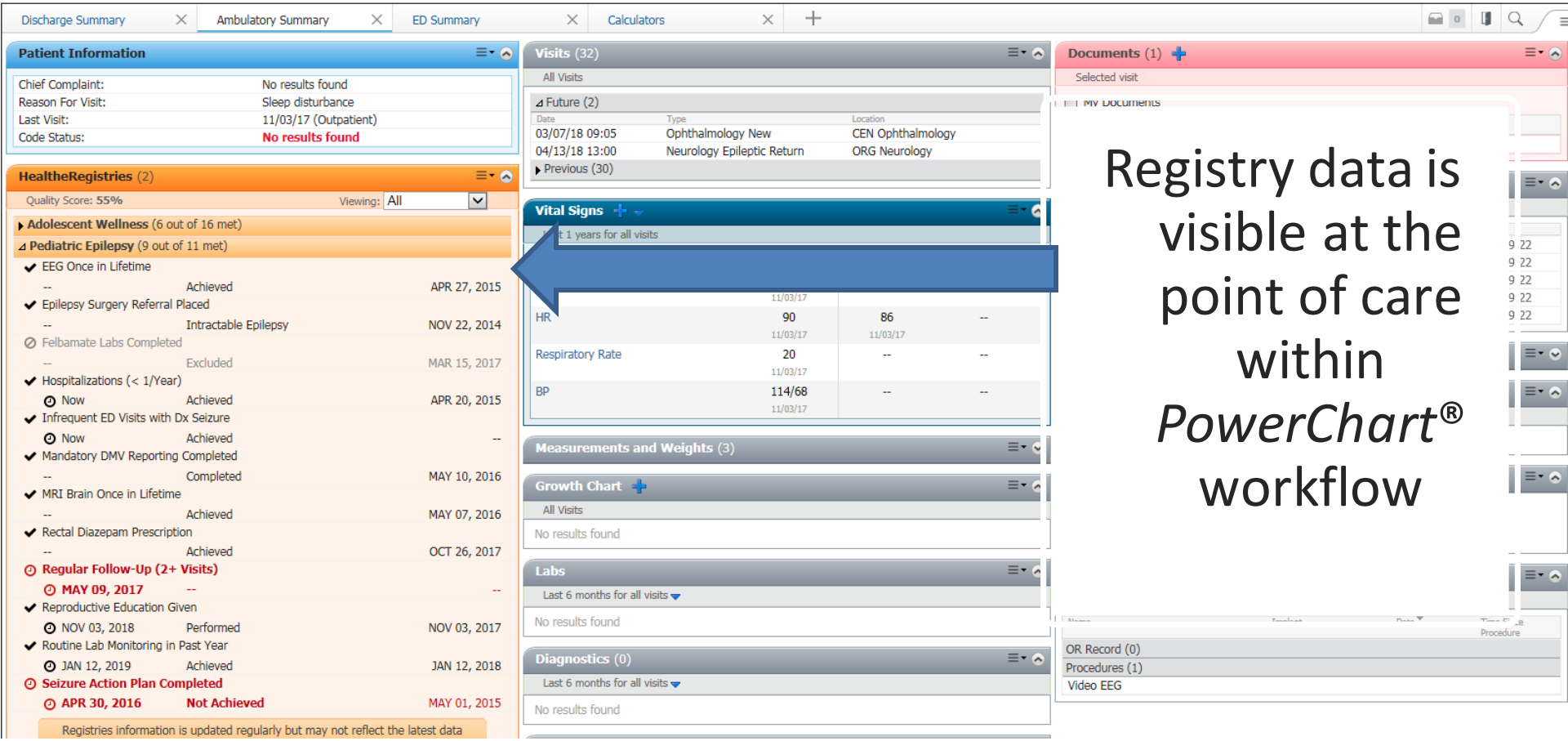


Why did we develop and implement condition-specific registries?

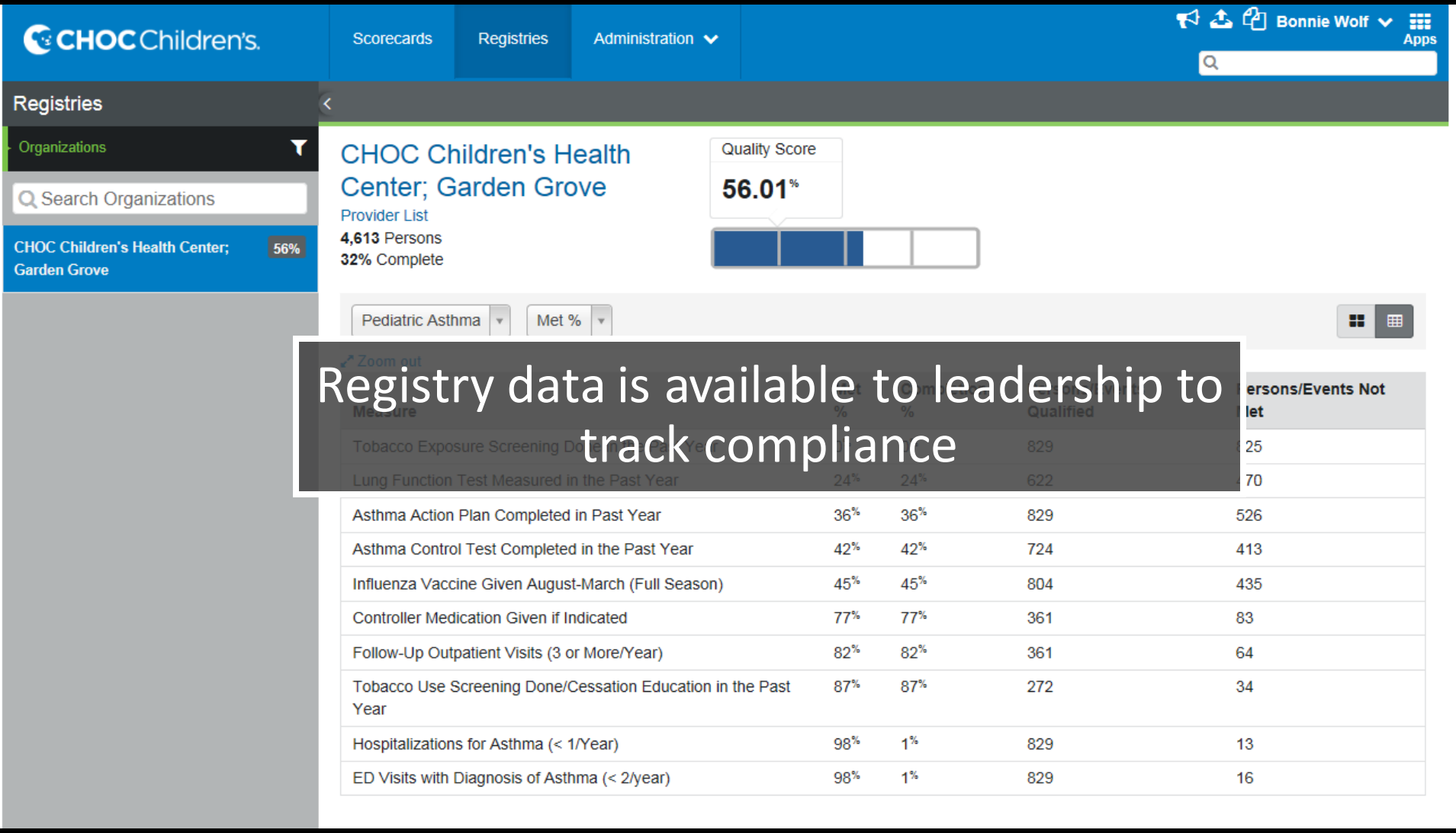
Cerner Pediatric HealtheRegistries®

- First seven CHOC and Cerner developed were:
  - Asthma (persistent, severe)
  - Diabetes
  - Seizures
  - Cardiomyopathy (CHF)
  - Inflammatory Bowel Disease
  - Well Child Care
  - Well Adolescent Care
- The next four were developed with our partners:
  - Sickle Cell Disease
  - Post-neonatal follow-up
  - Cystic Fibrosis
  - Down Syndrome
- Under development:
  - Autism
  - Patients with medical complexity


How do we gain value from registry use?



Registry data is visible at the point of care within *PowerChart*® workflow


CHOC Children's
Scorecards
Registries
Administration
Bonnie Wolf
Apps
Registries
Organizations
Search Organizations
CHOC Children's Health Center; Garden Grove 56%
CHOC Children's Health Center; Garden Grove
Provider List
4,613 Persons
32% Complete
Quality Score
56.01%
Pediatric Asthma
Met %
Zoom out
Registry data is available to leadership to track compliance
Measure
Qualified
Persons/Events Not Met
Tobacco Exposure Screening Done/Cessation Education in the Past Year 829 25
Lung Function Test Measured in the Past Year 24% 24% 622 70
Asthma Action Plan Completed in Past Year 36% 36% 829 526
Asthma Control Test Completed in the Past Year 42% 42% 724 413
Influenza Vaccine Given August-March (Full Season) 45% 45% 804 435
Controller Medication Given if Indicated 77% 77% 361 83
Follow-Up Outpatient Visits (3 or More/Year) 82% 82% 361 64
Tobacco Use Screening Done/Cessation Education in the Past Year 87% 87% 272 34
Hospitalizations for Asthma (< 1/Year) 98% 1% 829 13
ED Visits with Diagnosis of Asthma (< 2/year) 98% 1% 829 16

Clinic workflow has been augmented to integrate registries into daily activities

Our initial value focus was on primary care and asthma

- High prevalence in our at risk population (153,000 Medicaid full-cap lives)
- Most frequent cause of ED visits (5% of all ED visits)
- High rate of hospitalizations (10% of all hospital admissions)
- Large local variation in care
- High morbidity, poorly assessed

Improvement in compliance to Registry measures over time…

Primary care and each specialty with a relevant registry are selecting specific measures to track and improve.

Program Name for a Measure	Measure Name	Percentage of People Met	Person Count	Mapping required	PowerNote	Specialty
Pediatric Asthma	ED Visits with Diagnosis of Asthma (< 2/year)	9%	147	N	N/A	Pulmonology
Pediatric Asthma	Asthma Control Test Completed in the Past Year	79%	147	N	N/A	Pulmonology
Pediatric Asthma	Asthma Action Plan Completed in Past Year	81%	147	N	N/A	Pulmonology
Pediatric Epilepsy	Reproductive Education Given or Contraceptive Medication is Documented	4%	893	Y	Y	Neurology
Pediatric Epilepsy	Mandatory DMV Reporting Completed	43%	1042	N	N/A	Neurology
Pediatric Epilepsy	Labs Completed While Taking Antiepileptic Medication in the Past Year	50%	2857	N	N/A	Neurology
Pediatric Epilepsy	ED Visits for Seizures or Epilepsy or Status Epilepticus in the Past Year	97%	3184	N	N/A	Neurology
Pediatric Inflammatory Bowel Disease	ED Visits with Abdominal Pain, Diarrhea, Hematochezia, or Vomiting in the Past Year (< 2/Year)	6%	71	N	N/A	Gastroenterology
Pediatric Diabetes	Nutrition Assessment or Counceling in the Past Year	67%	1759	N	N/A	Endocrinology
Pediatric Diabetes	Most Recent HbA1c < 10.0%	77%	1759	N	N/A	Endocrinology
Pediatric Diabetes	ED Visits with Diabetes Ketoacidosis, Hyperglycemia, or Hypoglycemia (< 2/Year)	99%	1759	N	N/A	Endocrinology

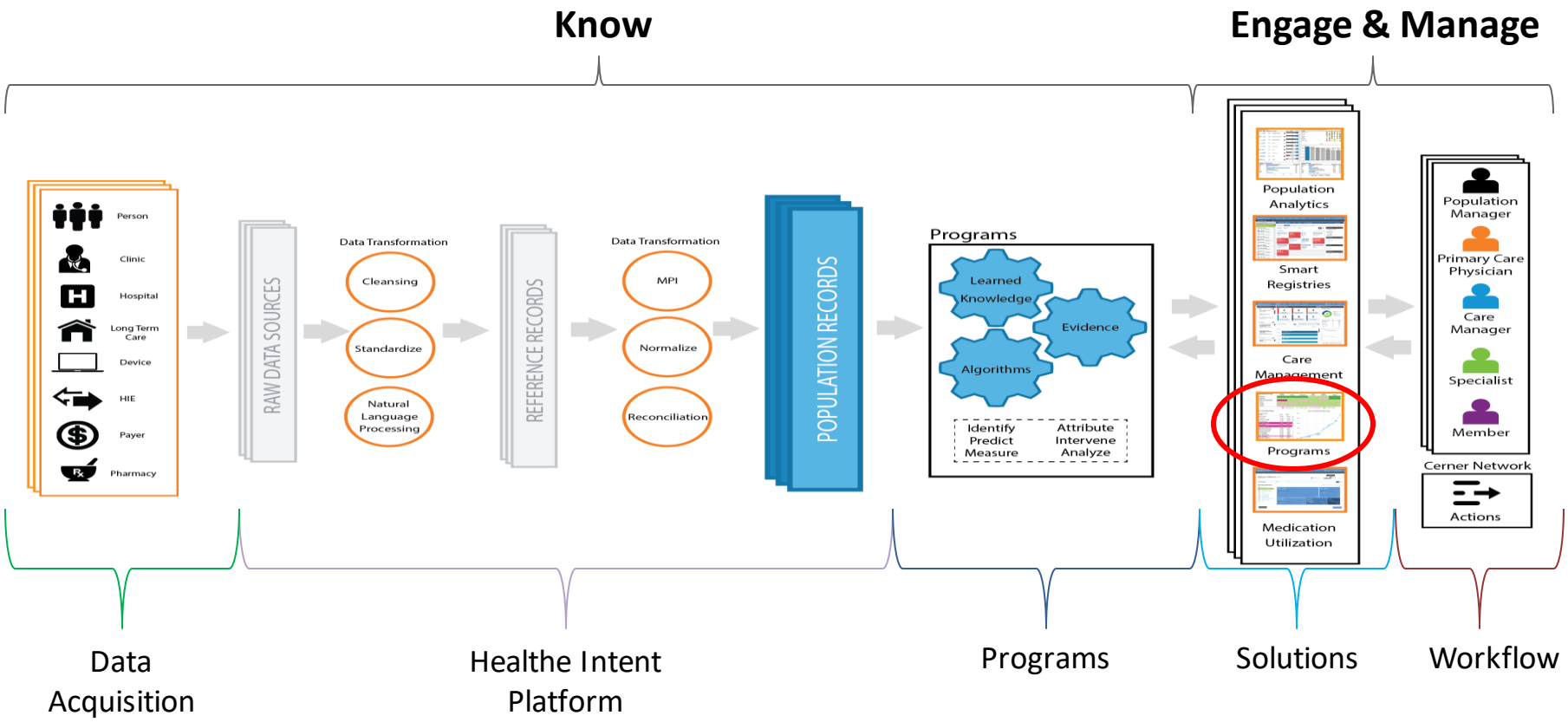
Why not just use the EDW to report on these measures? Do I need the Registries?

- In the Registry:
  - The population is defined (inclusion and exclusion criteria)
  - Relevant process and outcome measures are identified
  - The measures are defined (with inclusion and exclusion criteria)
  - The registry measures are mapped to data elements within the EDW
  - After mapping, the registry measures are validated against source data and credibility established with providers
  - The registry is attributed to providers with specific algorithms

Data curation is a broad term used to indicate processes and activities related to the organization and integration of data collected from various sources, annotation of the data, and publication and presentation of the data such that the value of the data is maintained over time, and the data remains available for reuse and preservation.

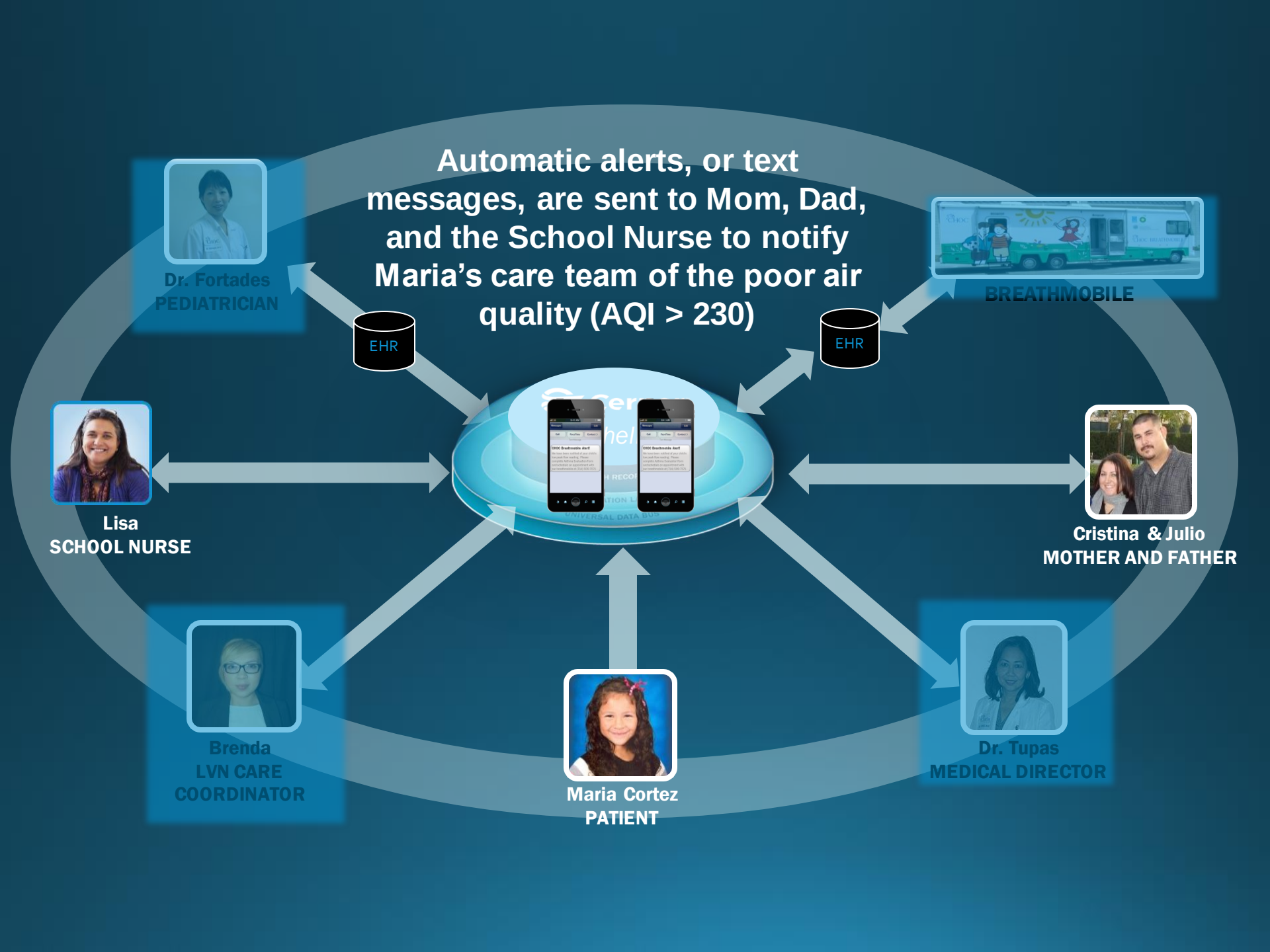
-Wikipedia

The *HealtheIntent*® platform



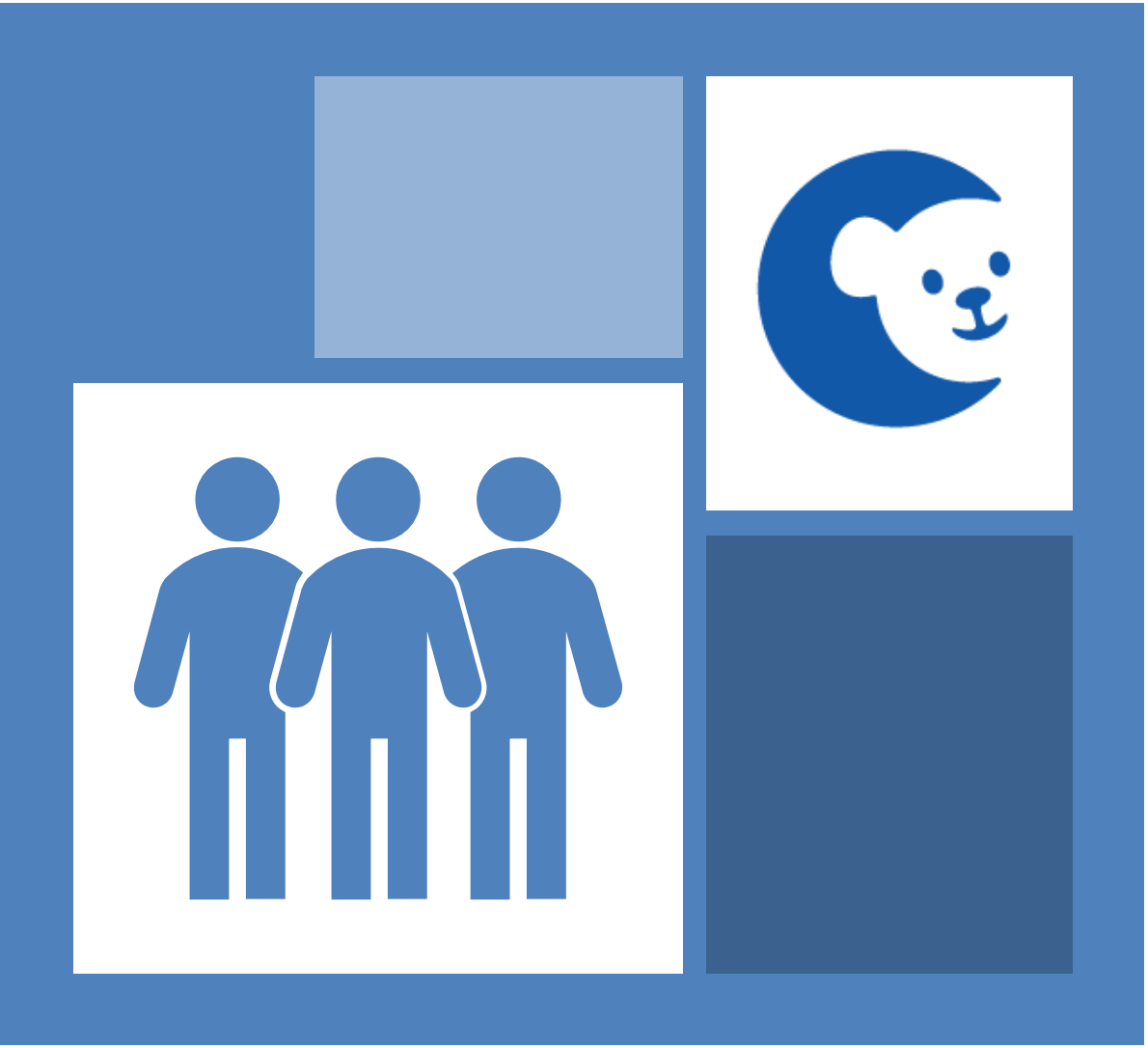
AI-based alerting for asthma

- Population of patients with asthma in HealtheIntent are analyzed for severity and diagnosis
- Big data sources like environmental data and social determinates will be imported into the system
- Remote monitoring device data collected in the system
- Alerts constructed and fed into the portal, care management platform to preemptively alert patients and caretakers


Automatic alerts, or text messages, are sent to Mom, Dad, and the School Nurse to notify Maria's care team of the poor air quality (AQI > 230)
Dr. Fortades
PEDIATRICIAN
BREATHMOBILE
EHR
EHR
Lisa
SCHOOL NURSE
Cristina & Julio
MOTHER AND FATHER
Brenda
LVN CARE
COORDINATOR
Maria Cortez
PATIENT
Dr. Tupas
MEDICAL DIRECTOR

Maria uses her spirometer at school and data imported into HealtheIntent

High-risk asthma patients are assigned a care manager who is also alerted. She can see Maria's asthma action plan, take into account a new peak flow reading and arrange for an early intervention to avoid an ED visit.



Applying Data Science to improve Quality and Patient Satisfaction

Applying Data Science to Patient Satisfaction Data

- We report this data throughout the organization and make plans based on assumptions on how we can improve our numbers
- How many organizations have sought to gain intelligence rather than using assumptions to formulate improvement plans?
- Did you know that the survey responses returned by outside agencies like NRC Picker include patient identifiers?
- Comparing responses, especially to a primary satisfaction indicator like likelihood to refer leads to unexpected results.
- For example…

Outpatient Surgery Patient Satisfaction

Ehwerhemuepha L, **Feaster W**, Kain Z: Impact of anesthesiologists on parental perioperative satisfaction scores. *Pediatric Anesthesia*. 2017; 27(9) 949-954

What we found

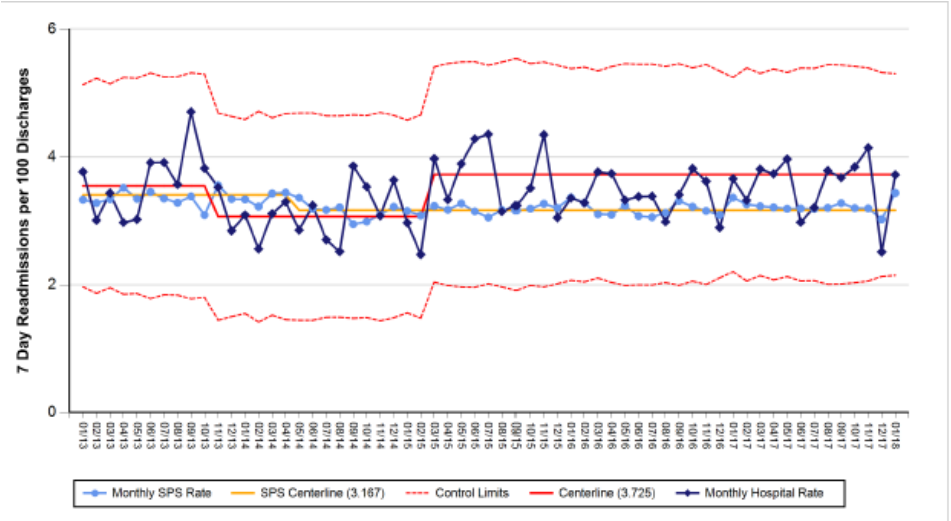
- Pain score in PACU, presence of post-op nausea and vomiting, time in PACU, on-time case start, and other items you'd expect were not statistically significant as predictors of patient satisfaction
- The perioperative communication with the anesthesiologist was the most likely predictor of patient satisfaction

Inpatient Satisfaction

Ehwerhemuepha L, Schultz S, **Feaster W**. Clinical and Psychosocial Factors Associated With Patient Experience. *Clinical Pediatrics*. 2017, Oct 1:9922817737078

What we found

- Low parental socioeconomic status was positively related to parental satisfaction, especially Spanish-speaking patients
- Parents of male children were much less likely to be satisfied than parents of female children
- Parent perception of provider-family communication and relationships placed very highly, as did having a hospital environment catering to children's needs



Annotations

09/17	Care Team - ED started
09/16	Care Team - Red started
05/16	Case Mgmt Refer To orders
11/15	Care Team - Blue started
08/15	Orders-F/U appts/tests by PAC
06/15	DC checklist/New Admit Booklet
04/15	DC phone call Cerner form
02/15	Med to Bed housewide
10/14	Med to Bed Pilot
09/14	Seizure Action Plan
03/14	Low risk oncology fever guideline
11/13	High risk groups analyzed
06/13	Readmission events emailed to MDs

- While CHOC has had great success in applying guidelines to care, and have reduced length of stay and readmissions for certain diseases, our overall 7-day readmissions (Solutions for Patient Safety metric) hasn't decreased for the overall organization, hovering at around 4% or near the national average for children's hospitals.
- We've tried many ways to improve this number without success
- We're now turning to data science…

Readmissions studies

7-day Readmissions

Ehwerhemuepha L, Bendig, D, Steele, C, Rakovski, C and **Feaster W**: The Effect of Malnutrition on the Risk of Unplanned 7-day Readmission in Pediatrics. Hosptial Pediatrics, 8(4), 2018.

What we found

- A novel statistical interaction between a patient's age and malnutrition affecting the odds of a 7-day readmission
- Younger malnourished patients were up to 5 times more likely to be readmitted than malnourished teenagers
- The opposite was true for children that were not malnourished

30-day Readmissions

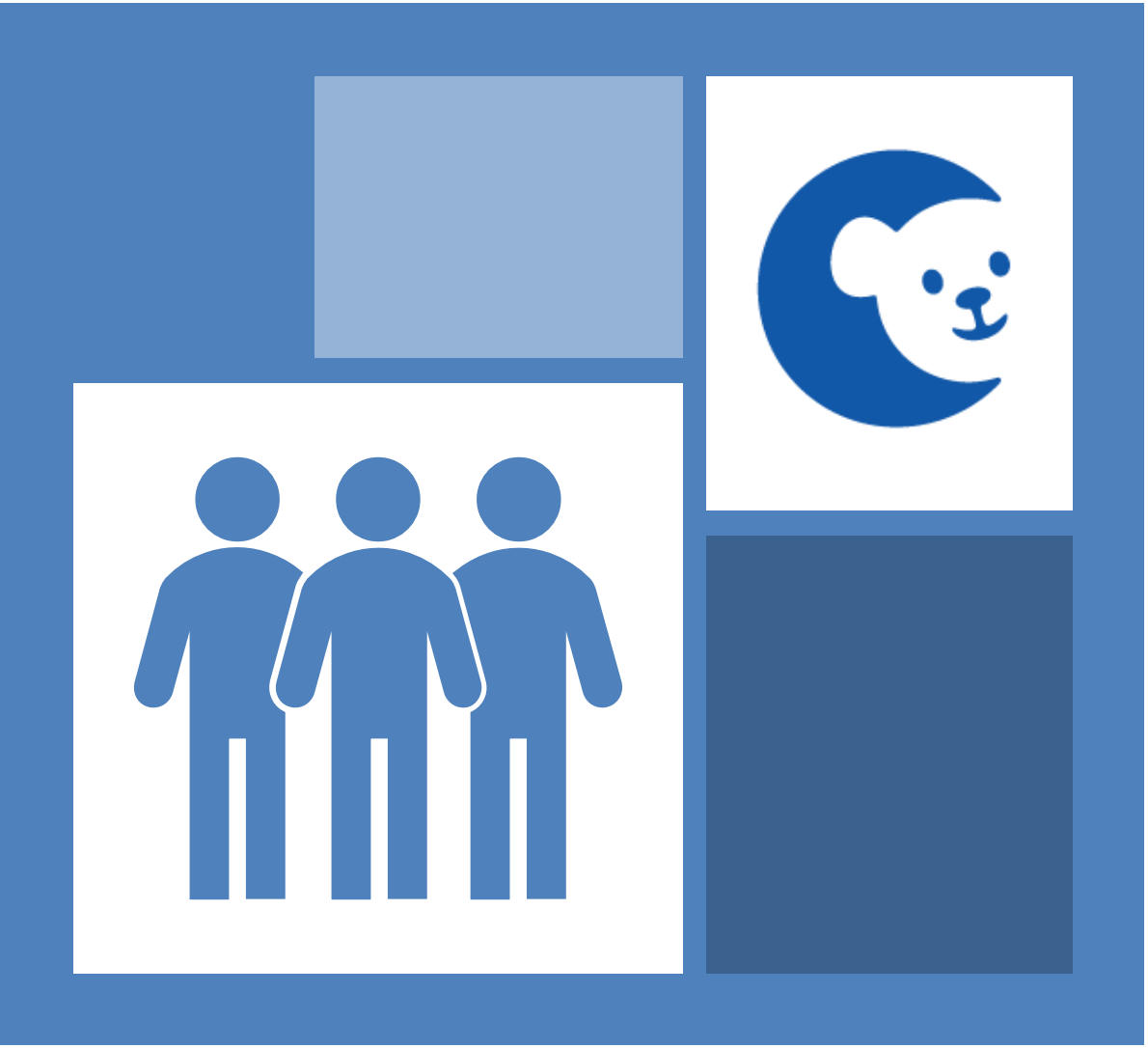
Ehwerhemuepha, L., Finn, S., Rothman, M., Rakovski, C. and Feaster, W., 2018. A novel model for enhanced prediction and understanding of unplanned 30-day pediatric readmission. In Press, Hospital pediatrics.

30-day Readmissions

- Algorithm predicts both 7 and 30-day readmissions
- Study takes into account novel variables to predict readmission including:
  - Rothman Index
  - Prior readmissions and whether current admission is a readmission
  - Medication classes
- Best AUC 0.79
- Subsequent work has increased that to 0.83 with 86 variables now in the model

Implementing the readmission algorithm

- At 7 am each morning, the algorithm is run on all patients on the med/surg floors
- The algorithm gives a probability of readmission for all patients
- The high-risk group is considered to have a probability of readmission of greater than 0.22
- Risk threshold chosen to alert, on average, 3 patients per day that are scheduled for discharge so as not to over burden staff with low level alerts.



Exploring data with advanced artificial intelligence tools

While we have made great progress, we've been limited by our computing resources

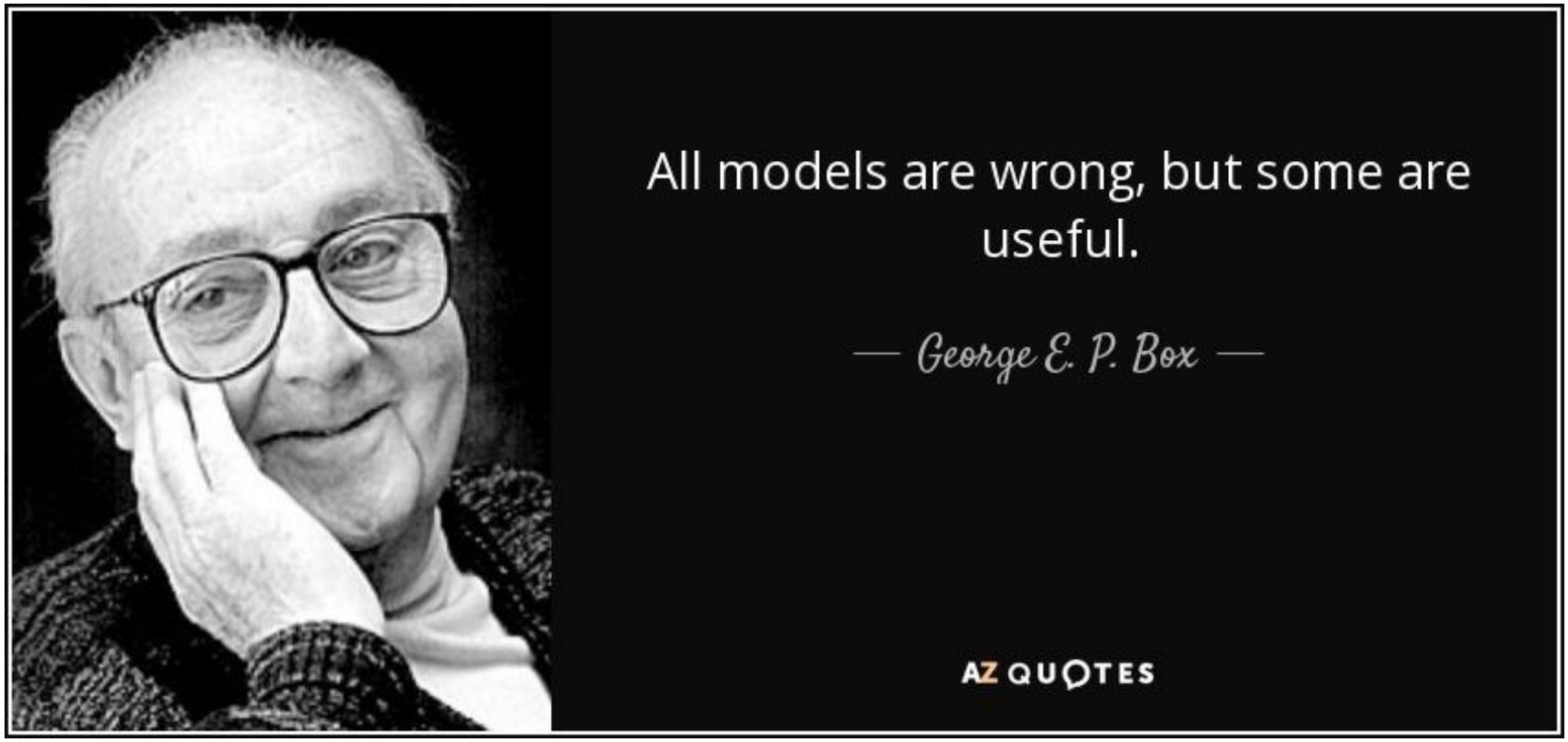
- Discrete data used for our projects are extracted into a rapidly expanding data warehouse.
- Our data scientist manipulates this data with a server equipped Invidia Tesla GPU cards, but some of the calculations in a model using multiple variables may take days to run.
- We are still limited by selecting data to expose any model to, rather than letting the machine learn from a larger data set.

Enter HealtheDataLab

- Cerner approached us to be a development partner for a new cloud computing and big data platform utilizing AWS
- Data from our HealtheIntent instance is now uploaded into AWS
- Data elements are modelled along HL-7 FHIR standards as applicable, and other data sets can be loaded into the same AWS “bucket” for analysis without performance and size limits
- This will facilitate the use of Machine and Deep Learning techniques

Our pilot projects for HealtheDataLab

- Patient deterioration
  - Inpatient mortality model of patient deterioration
  - Predicting transfers to the PICU: predict transfer early enough to avoid complicated PICU care for late transfers
- Primary care no-show tendency
  - Classify patients based on their probability of missing an appointment


All models are wrong, but some are useful.
— George E. P. Box —
AZ QUOTES

Q&A

William W. Feaster, MD, MBA
Chief Health Information Officer, Children's Hospital of Orange County (CHOC)

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