Improving Population and Individual Healthcare Outcomes with Machine Learning Analytics

Lonny Northrup, Sr. Medical Informaticist
Intermountain Healthcare

- 22 hospitals
- 39,000 employees

1975

- 850,000 members
- 25% market share

1983

- 200 clinics
- 1,200 employed physicians

1994
Helping people live the healthiest lives possible.
Data Value Cycle

Data

Patient Care
(Primary Applications & Data)

Data Integration
Data Modeling
ETL, etc.

Research
Decision Support

Ideas
Improveed Care

Insight
(Secondary Data Use)

Data Governance & Knowledge Management

Master Data Mgmt
Data Stewardship
Data Quality

Data Security
Data Lifecycle Mgmt
Metadata/Std Metrics

Action
Intermountain Data & Analytics Services
Organizational Structure

Intermountain Healthcare
Data & Analytics Services

Data Warehousing and Integration
- Organizing Data for Analysis
- Integration of Disparate Data (EDW)
- Data Movement

Data Governance
- Data Stewardship / Ownership – train and enable business to engage in data management processes
- Data Quality Management
- Tools for defining business terms and metrics (metadata)

Data Semantics and Clinical Modeling
- Data Standardization, Shared Data Services
- Reference Data (ICD codes, Zip codes, etc.) Management
- Master Data (provider, patient, locations) Management
- Clinical Data Modeling

Analytics and Data Science
- Enterprise Data Analyst Coordination
- Data Analyst Best Practices
- Data Science = predictive analytics, integration into decision processes

Analytic Technology Services
- Technologies & Tools to support data analysts
- Enterprise-level dashboard and analytic solution dev.

Data & Analytics Advancement
- Coordinate innovation efforts for data and analytics
Intermountain Data & Analytics Governance

- Intermountain Operations Council
- Data & Analytics Governance Committee
- Data & Analytics Council
  - Data & Analytics Project and Priority Governance
  - Data & Analytics HR Committee
  - Analytics Leadership Council
  - Data & Analytics Advancement/Innovation Committee
  - Data Governance Council – DG Office – Data Steward Council
# Intermountain Data & Analytics Architecture

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Intermountain Data & Analytics Architecture
## Intermountain Data Sources

### Functional Areas

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<td>Musculoskeletal Clinical Program</td>
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<td>Pain Management Clinical Service</td>
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<td>Genomics</td>
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<td>Strategic Planning and Research</td>
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<td>Health Information Management</td>
<td>Pathology &amp; Laboratory Medicine</td>
<td>Supply Chain Organization</td>
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<td>Home Care</td>
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<td>HR and Payroll</td>
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<td>Imaging Clinical Service</td>
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<td>Infection Control</td>
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<td>Women &amp; Newborns Clinical Program</td>
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Intermountain Data & Analytics

Analytic Types

- **Descriptive** *(What has happened)*  Financial and operational reporting, cost analysis, quality and compliance, meaningful use, etc.
- **Diagnostic** *(Why things happened)*  Outcomes analysis, gaps in care, fraud detection, etc.
- **Predictive** *(What will happen)*  Population health risk stratification, contract forecasting and modeling, diagnostic clinical decision support, etc.
- **Prescriptive** *(What should happen)*  Care process models, prescriptive clinical decision support, precision medicine, etc.
- **Personalized** *(What should each person do?)*  Individual cost predictions and treatment recommendations

Analytic Methods and Tools

- **Delivered Reports**  Emailed, scheduled, etc.
- **Self-Service Reports**  User executed on demand
- **Self-Service Dashboards**  Analyst configured and user queried on demand
- **Data Discovery / Data Preparation**  Analysts and data managers exploring cubes and indexes
- **Predictive and Algorithms**  Advanced statistical analysis
- **Analytic Applications**  Purpose built analytics, custom alerts and embedded analytics
- **Machine Learning / Cognitive Computing**  Advanced analytics
Intermountain Data & Analytics
Rich Legacy of Data Driven Results

• **Heart Failure Mortality Rates**
  Less than half the national average

• **Sepsis Mortality Rates**
  Less than half the national average

• **Reduction of Elective Inductions**
  Elimination of elective inductions prior to 39 weeks. NICU utilization reduced by nearly 50%. Projected $5.3B annual savings if adopted nationwide.

• **Colon Surgery**
  $1.2 million annual savings, LOS decreased from 8.44 to 6.75 days, while maintaining or improving clinical quality. - *Computerworld Business Intelligence Award – Driving Process Change with BI*

• **Surgical Price Reduction**
  Nearly $60M cost reduction for knee and hip replacement over 3 years while improving clinical outcomes

• **Other Clinical Quality Improvements**
  Diabetes, asthma, community acquired pneumonia (CAP), blood utilization, 50+ standardized care processes

• **Healthcare Operations Improvements**
  Lab operations, supply chain, operating room (OR), hospital operations, patient satisfaction, core measures, meaningful use, population health, shared accountability
Industry Validation – Healthcare Provider Collaboration
Intermountain Approach: *Early fast follower of proven value*

- Collaboration with over 400 of the leading healthcare providers
  - Share lessons learned
  - Find the latest emerging and validated successes
  - Validate vendor claims to reduce lost time, resources and investments

- Healthcare Data and Analytics Association (HDAA)
  - Founded in 2001 to serve as a forum where healthcare organizations planning or engaged in data and analytics can share ideas and lessons learned. HDAA is a volunteer based organization supported completely by the participating members. http://www.healthcaredataanalytics.org

- Health Management Academy (HMA)
  - Founded in 1998, The Health Management Academy is comprised of executive members from the country’s largest integrated health systems and the industry’s most innovative companies. Executive members exchange best practices and benchmark information on increasing the quality and efficiency of healthcare through structured interaction among its health system members. https://academynet.com/
Big Data and Machine Learning

Definitions
What is Big Data?
Intermountain’s Definition

Using additional data sources and new analytic tools to produce superior, actionable analytic insights (not previously possible or cost effective) leading to:

• Improved Healthcare Outcomes
• Reduced Cost
• Healthier People

Value = Results / Costs

NOTE: Volume, Variety and Velocity (and sometimes Veracity) are frequently used to describe big data. For Intermountain, our primary measure is Value.
What is Machine Learning in Healthcare?

Machine learning, cognitive computing, artificial intelligence and deep learning are related terms. Collectively, they refer to the ability of computers to learn from data how to replicate and improve human predictions and decisions.

In healthcare this means consuming a variety of data (clinical, cost, claims, patient characteristics, etc.) to produce actionable insights leading to lower cost and more effective healthcare outcomes.
Augmented Medical Intelligence

Machine Learning (cognitive computing, artificial intelligence, deep learning, etc.) assists humans to make better decisions and take better actions, but cannot completely replace people in the processes of achieving the very best outcomes.
Big Data and Machine Learning in Healthcare

Actual Results (Industry Examples)
Machine Learning in Healthcare
Actual Results Being Achieved – NOW (1 of 3)

• Deriving optimal care delivery for specific procedures like total knee replacement (Mercy Healthcare, Missouri – Ayasdi)

• Improvements in predicting pre-term births using genomic data (Inova – GNS Healthcare)

• Improved colon cancer screening using data from simple historical lab tests (Maccabi Isreal – Medial Early Sign)

• Improved diagnosis of heart conditions from echocardiogram results (Mt. Sinai – Saffron (acquired by Intel))

• Detecting disease states from medical imaging (Clalit Isreal – Zebra Medical)

• Other conditions improved through machine learning insights (GNS Healthcare)
  - Cardiovascular disease
  - Metabolic Syndrome
  - Multiple Myeloma
  - Diabetes
  - Rheumatoid Arthritis
  - Parkinson’s disease
  - Multiple Sclerosis
  - Huntington’s disease
  - Alzheimer’s
  - Colon Cancer
Machine Learning in Healthcare
Actual Results Being Achieved – NOW (2 of 3)

• **Machine Learning driven Patient Engagement**
  - Type 2 Diabetes Prevention: 58% to 85% risk reduction for over 70% of participants (*Omada*)
  - Diabetes: Average 3.2 drop in HbA1c in 3 months (typical drop is 0.5 to 1.0 in 1 year) (*Twine Health*)
  - Congestive Heart Failure: 4% readmission rate compared to national average of 26-28% (*Sensely*)
  - Remote Patient Monitoring: 89% reduction in inpatient visits, 70% reduction in emergency department visits (*Vivify*)
  - Chronic Obstructive Pulmonary Disease (COPD): 87% adherence to care plan, 92% medication adherence and more than 70% reduction in hospitalizations (*Senscio*)

• **Real Time Machine Learning driven Emergency Department Optimization**
  - 20% reduction in door to doc time (*AnalyticsMD*)
  - 30% reduction in Leave Without Being Seen (LWBS) rate (*AnalyticsMD*)
  - 13% reduction in length of stay - (*AnalyticsMD*)
Machine Learning in Healthcare
Actual Results Being Achieved – NOW (3 of 3)

• Machine Learning driven **Personalized Treatment Recommendations**
  • $895,000 in savings in under 3 months and significantly reduced readmissions (Health First, Florida - *Jvion*)
  • $4M in savings from readmission reductions (University of Tennessee Medical Center - *Jvion*)
  • Reduced Catheter Associated Urinary Tract Infections (CAUTI) (*Jvion*)
  • Over 60 areas of clinical outcomes improvement (*Jvion*)

**Over One Million** lives improved through over **3.3 Billion** individual patient considerations (*Jvion*)

**Over 24 Thousand** lives saved through over **6.2 Billion** individual answers served (*HealthTap*)
Big Data and Machine Learning At Intermountain
Big Data and Machine Learning at Intermountain
Most Significant New Data Sources and Analytic Tools

**New Data Sources**
- Genomic Data
- Device Data
- Patient Reported Data

**New Analytic Tools**
- Machine Learning (cognitive computing, artificial intelligence, deep learning, etc.)
- Health Activation (patient engagement, population health, personalized medicine, shared accountability, etc.)
Big Data and Machine Learning at Intermountain Retaining Physiologic Monitor Data for Analysis – Hortonworks Hadoop

Combining streaming device data and clinical event data
Big Data and Machine Learning at Intermountain
Genomic Variant Analysis for Precision Medicine – Syapse

- Precision medicine clinical workflow, enabling oncologists to make treatment decisions informed by genomic data and track clinical impact.
- Enabled Molecular Tumor Board, providing decision support to clinicians by recommending targeted therapies and clinical trials.

- Increased drug procurement rate 5-fold, to 82%.
- Increased progression-free survival of advanced cancer patients by 92% with no increase in total cost of care.

Matching patients to precision cancer treatments
Big Data and Machine Learning at Intermountain
Real Time Threat Detection and Security Analytics – Securonix

- Insider Threat Management
- User & Entity Behavior Analytics
- Identity and Access Analytics
- Application Security Analytics

- Network Security Analytics
- Privileged Account Analytics
- Threat Intelligence
- Continuous Risk Monitoring
- Activity Monitoring

Monitoring and analyzing up to billions of events per day
Big Data and Machine Learning at Intermountain
Driving Variance Out of Care Processes – Care Process Models* (CPM)

Nearly 60 CPM’s Today

- Behavioral health
- Cardiovascular
- Collaborative Pharmacy
- Imaging Services
- Intensive Medicine
- Musculoskeletal
- Oncology
- Pain Services
- Pediatric
- Primary Care
- Surgical Services
- Women and newborns
- Etc.

Reducing variance from knee and hip replacement surgeries alone resulted in $60M savings over 3 years AND delivered improved outcomes

* Link to Intermountain Care Process Models: https://intermountainphysician.org/clinical/Pages/Care-Process-Models-(CPMs).aspx
Big Data and Machine Learning at Intermountain
Optimizing Care Process Models - Ayasdi

Optimizing existing models and accelerating development of new models
Big Data and Machine Learning at Intermountain
Detecting Disease States in Medical Imaging – Zebra Medical

- Osteoporosis
- Emphysema
- Fatty Liver
- Coronary Calcium
- Pulmonary Hypertension

Pilot activity, validating existing models. Potential to develop new models by training on our 3 billion+ medical images
Big Data and Machine Learning at Intermountain
Unstructured Text and Natural Language Processing (NLP)

- Assisted Chart Extraction – claims coding, quality measures, registry population, research cohort selection
- Pneumonia – real time predictive diagnosis in emergency department
- Infectious Disease – coding patient susceptibility testing
- Complex Cohort Identification – identifying complex criteria to predict invasive fungal disease

NLP is very most effective in specific contexts where source data is relatively consistent

- Hydronephrosis Severity – classify severity of Hydronephrosis (kidney swelling) in utero pregnancy ultrasounds
- Bio Surveillance Outbreak Detection – viral pulmonary models for pandemic and outbreak detection for Influenza, parainfluenza and respiratory syncytial virus
Big Data and Machine Learning At Intermountain

Where Do We Go Next?
Big Data and Machine Learning at Intermountain
Where Do We Go Next?

- Individual Cost Prediction
  - $$
- Individual “Next Best Action” Care Plan
  - N of 1
- Continuous Connection to Care Team
  - 24/7

Personalized Medicine
QUESTIONS