The Future of Patient Reported Outcomes in Neurosurgery: the Impact of Big Data, Predictive Analytics, and Wearable Technology

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Outline

- Learning Objectives
- Background
- Vision
- Team
- Work
- Future
Learning Objectives

1. Describe the unique advantages of predictive analytics based on combined administrative, financial, and clinical data streams
2. Understand the importance of big data and wearable technology to neurosurgical outcomes research
3. Identify current and future trends for outcomes tracking in neurosurgery
Outline

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☐ Background
☐ Vision
☐ Team
☐ Work
☐ Future
What Is Value in Health Care?

Michael E. Porter, Ph.D.

STRATEGY

The Strategy That Will Fix Health Care

by Michael E. Porter and Thomas H. Lee, MD

➢ Shared goals for all stakeholders
➢ Accountability - IPU
➢ Competition
Dave Wofford: Making Way for MACRA: Positioning Your Organization for Payment Reform
Surgeon Scorecard

by Sisi Wei, Olga Pierce and Marshall Allen, ProPublica, Updated July 15, 2015

Guided by experts, ProPublica calculated death and complication rates for surgeons performing one of eight elective procedures in Medicare, carefully adjusting for differences in patient health, age and hospital quality. Use this database to know more about a surgeon before your operation.
A Methodological Critique of the ProPublica Surgeon Scorecard

Mark W. Friedberg, Peter J. Pronovost, David M. Shahian, Dana Gelb Safran, Karl Y. Bilimoria, Marc N. Elliott, Cheryl L. Damberg, Justin B. Dimick, Alan M. Zaslavsky
Donabedian’s Quality Framework

Structure → Process → Outcomes

Characteristics of institutions & providers → What is done to the patient → What happens to the patient

Caregiver Experience of Care

IHI
Outline

✓ Learning Objectives
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Founded in 2015 by Dr. Timothy R. Smith and Dr. William Gormley
Mission Statement

The Cushing Neurosurgery Outcomes Center centralizes disparate administrative, clinical, and financial data sources and detailed outcomes tracking and reporting in order to internally increase quality improvement guidelines for high value care at Brigham and Women’s Hospital and Partners Healthcare and externally synthesize “big data” to inform best practices and protocols for the international neurosurgical community.
Partnerships
Team

Brigham and Women’s Hospital
- Neurosurgery Faculty
- Neurosurgery Administrators
- Neurosurgery Residents
- Practice Extenders (PA, NPs, etc.)
- Anesthesiology/Pain, Radiology, Otolaryngology, Endocrinology, Pathology, Neurology, Psychiatry, Oncology, Orthopedic Surgery, Radiation Oncology, Ophthalmology Faculty

Harvard University
- Medical Students
- Graduate Students
- Post-Docs
- Undergraduates
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What we do:

- Big Data
- Predictive Analytics
- Wearable Tech
Patient Reported Outcome Measures - PROMS

- Traditional
- Modern
DATA and sensors

• Progress in science always driven by data
• Dramatic increase in data volume and type
• Big Data refers to large and complex data sets
  • Volume, Velocity, Variety

• Origin in Moore’s law
  • Transistor density doubles every 18 months

• Data: Sensors are cheap, small, everywhere
• Analysis: Computational capacity

• Methods: “Space age data require space age methods”

http://en.wikipedia.org/wiki/Moore%27s_law
• 64% of American adults own a smartphone in 2015
• Up from 35% in 2011

U.S. Smartphone Use in 2015, Pew Research Center, 2015
U.S. Smartphone Use in 2015, Pew Research Center, 2015
Digital phenotyping

- **Definition:** “Moment-by-moment quantification of the individual-level human phenotype *in situ* using data from personal digital devices

- **Goal:** Capture the lived experiences of subjects, and their interactions with the surrounding world, with minimal interference

- **Active data**
  - Standardized measures (ex. ODI, SF-36, Pain scale, PHQ-2)

- **Passive data**
Spine Surgery and Brain Tumor Patients

1. Traditional Surveys
2. Smartphone Enabled Surveys
3. Passive Data
Data Streams

Data streams

• Accelerometer (x acceleration, y acceleration, z acceleration)
• GPS (latitude, longitude, precision)
• Phone / screen usage (screen on/off, phone on/off, reboots, plug in/unplug)
• Nearby WiFi routers (hashed MAC address, signal strength)
• Bluetooth devices (hashed MAC address, signal strength)
• Phone call logs (incoming, outgoing, missed, time, call duration, hashed number)
• Text message logs (incoming, outgoing, time, message length, hashed number)
• Survey data (daily & weekly; survey metadata)
• Voice recordings

• More than 1 million data points per day per subject
PRIVACY

Privacy

• Password protection
• Data buffered on the device until next WiFi network available
• Beiwe does not store any personal identity information
• Participants are assigned randomly generated IDs (e.g., DT4TIY86)
• Potential identifiers, like phone numbers, in collected data are hashed using industry-standard SHA-256 hashing algorithm
• All data on phones, on the server, and in-transit use industry-standard encryption techniques
• Beiwe uses asymmetric encryption (cannot read its own data)
• Public 2048 bit RSA encryption key, which is then used to encrypt a symmetric AES (Advanced Encryption Standard) key for bulk encryption (generated as needed by the app)
BEIWE DATA: GPS

- Map: https://mkiang.cartodb.com/viz/c67b3202-2023-11e5-96ef-0e853d047bba/public_map
- Animation: http://cdb.io/1GvZefN
ACCELEROMETER
Classification with Decision Trees

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<th>Off person</th>
<th>Stand/Sit</th>
<th>Walk</th>
<th>Run</th>
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COMMUNICATION PATTERNS
Audio diaries

- Collect high-quality audio using the smartphone’s microphone
- Vocal markers for depression
You’re already carrying a powerful medical research tool.

ResearchKit
National Databases

American College of Surgeons (ACS)
- National Surgical Quality Improvement Program
  - Adult, NSQIP
  - Pediatric, NSQIP - P

Agency for Healthcare Research and Quality (AHRQ): Healthcare Cost and Utilization Project (HCUP)
- National Inpatient Sample (NIS)
- State Inpatient Databases (SID)
- Kids Inpatient Database (KID)
- National Readmissions Database (NRD)

Children’s Hospital Association (CHA)
- Pediatric Health Information System (PHIS)
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<th>Longitudinal</th>
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Karhade AV, Larsen AMG, Cote DJ, Dubois HM, Smith TR. "National databases for surgical outcomes research: options, strengths, and limitations." *In submission*
IBM Watson Health Announces Plans to Acquire Truven Health Analytics for $2.6B, Extending Its Leadership in Value-Based Care Solutions

IBM’s Fourth Major Health Data-Related Acquisition in the Past Year
Watson Health Quickly Building One of the World’s Largest and Most Diverse Repositories of Health-Related Data
Cushing Neurosurgical Outcomes Center @ Harvard

Aditya V. Karhade, BE, William B. Gormley, MD, MPH
Department of Neurosurgery, Brigham and Women's Hospital, Harvard Medical School

- Big Data
- Predictive Analytics
- Wearable Tech
PREDICT. PREPARE. PREVENT.

Turn healthcare data - any type, any format - into actionable insights faster and with greater accuracy than ever before possible.
Methods of Learning from Clinical Data

Accuracy

# Variables Considered

Machine Learning + NLP: All available data

Rules-based: “hit or miss”

Statistics: 7 to 10 structured variables

Cyft.
**Current Approach**

- Business user defines target / question.
- Analyst creates custom data transforms.
- NLP expert creates custom rules for text processing.
- NLP expert / business design & evaluate experiments.
- ML expert creates custom algorithms.
- Business / ML / Statistician design & evaluate experiments.
- Developer creates custom software to deploy models.

**Cyft.**

- Business user loads data – no special format required. Defines target / question.
- Cyft automatically creates & evaluates hundreds of models using millions of data points.
- Business user reviews results, deploys to production.

**Hours of effort**

- The evolution of predictive analytics from specialized & expensive to accessible & affordable

**Months of effort**
Lumbar Spine Surgery

- Laminectomy
- Fusion
- Discectomy

Discharge Disposition

- Routine
- Non-routine
Data Thinking

- Access – getting your hands on the data
- Structure – getting it to “apples to apples” so you can do the math
- Analysis – learning what matters
- Interaction – putting it to use: right place, time, people, presentation

L. D'Avolio “Data thinking in health care” The HealthCare Blog
The algorithm’s the easy part

Context

Interaction

Analysis

Structure

Access

L. D’Avolio “Data thinking in healthcare” The Healthcare Blog
Context

• Who owns the data and how can you gain access? (access)
• How is the data currently formatted and what challenges will this create? (structure)
• What methods are best suited to arrive at answers that users can trust? (analysis)
• Who exactly will employ the results and how will they employ them? (interaction)
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Delayed Symptomatic Hyponatremia

- Most common life threatening post-operative complication after transphenoidal resection of sellar lesions
- Presents 4-14 days post-operatively
- Nausea, vomiting, dizziness → seizures, death
- Gold standard: serum sodium levels and fluid restriction
- Readmissions
Cushing Neurosurgical Outcomes Center @ Harvard
Smith TR¹, Rambachan A, Cote D, Cybulski G, Laws ER.

Neurosurgical Defensive Medicine in Texas and Illinois: A Tale of 2 States
David J. Cote, Aditya V. Karhade, Alexandra M.G. Larsen, Joseph P. Castlen, Timothy R. Smith

Length of hospital stay after craniotomy for tumor: a National Surgical Quality Improvement Program analysis
Hormuzdiyar H. Dassenbrock, MD, Kevin X. Liu, DPhil, Christopher A. Devine, MPhil, Vamsidhar Chavakula, MD, Timothy R. Smith, MD, PhD, MPH, William B. Gormley, MD, MPH, and Ian F. Dunn, MD
How a Lumbar Diskectomy Influenced Medical Malpractice and the Landscape of Health Care


Venous thromboembolism in brain tumor patients

David J. Cote, Timothy R. Smith*

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Comparison of the Efficacy and Safety of Endovascular Coiling Versus Microsurgical Clipping for Unruptured Middle Cerebral Artery Aneurysms: A Systematic Review and Meta-Analysis

Timothy R. Smith¹, David J. Cote¹, Hormuzdiyar H. Dasenbrock¹, Youssef J. Hamade², Samer G. Zammã², Najib E. El Tele³, H. Hunt Batjer³, Bernard R. Bendok²
Cushing Neurosurgical Outcomes Center @ Harvard

Summary

- Research Based
- Innovation Through Analytics
- Patient Centered
- Value-Based Care
- Knowledge Creation
- Education Driven
WHY IS A DEDICATED OUTCOMES CENTER KEY TO THE FUTURE OF NEUROSURGICAL PRACTICE?

- BIG DATA
- PREDICTIVE ANALYTICS

HOW DOES THIS UNIFY ADMINISTRATIVE & FINANCIAL STRATEGY WITH IMPROVED PATIENT CARE?

- VALUE AGENDA
- NATIONAL HEALTHCARE REFORM
- PUBLIC REPORTING
- PERSONALIZED PATIENT CARE
Questions?