NATIONAL REFERENCE LABORATORY

UNIVERSITY OF UTAH
SCHOOL OF MEDICINE

Department of Pathology

Quantifying and Communicating that Information Content of Laboratory Tests

Brian Jackson, MD, MS
Assoc Prof of Pathology (Clinical), University of Utah
Adjunct Asst Prof of Biomedical Informatics, Univ of Utah
Medical Director of Informatics, ARUP Laboratories

Disclaimer

Conceptual, not practical

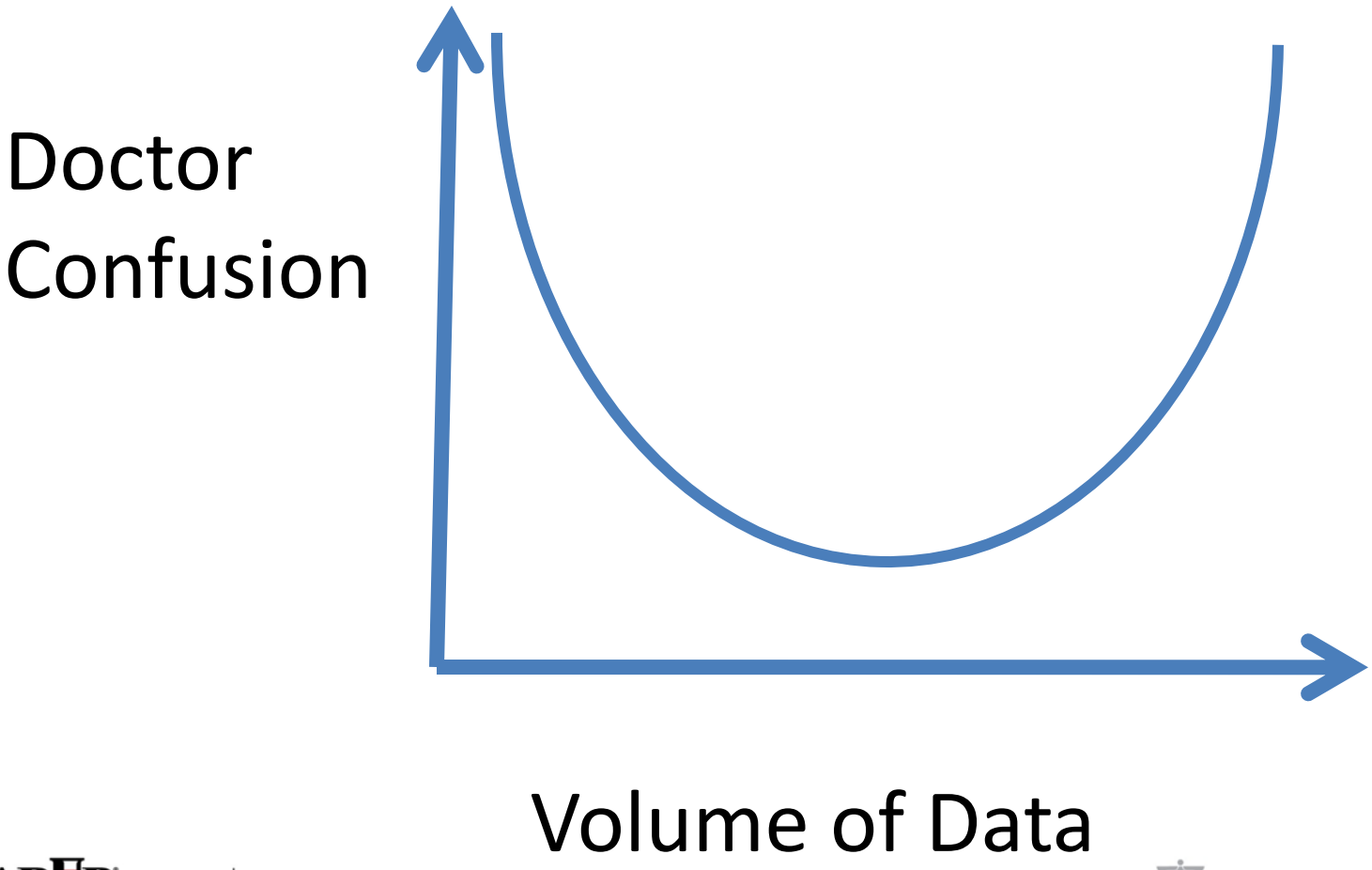
No answers

Hopefully some questions

Problem #1:
Lab Data is Oversimplified

- HL7 Format dictates what/how we communicate
- Focus on discrete results
- No incorporation of:
  - Patient's previous results for this assay
  - Patient's results for other relevant assays
  - Non-lab data (imaging, history, meds, etc.)
  - Analytic variation
  - Biologic variation

Problem #2:
Lab Data is Too Complex



Problem #3:

Lab Data is only part of the story

Study of diagnostic accuracy:

- 442 Medicine service admissions through E.D.
- 20% diagnosed correctly on history alone
- 1% diagnosed correctly on lab tests alone

BUT…

- Lab tests raised accuracy of Hx+PE

  from 50% to 80%

--Paley et al. Arch Int Med 2011

Integrative Diagnostics

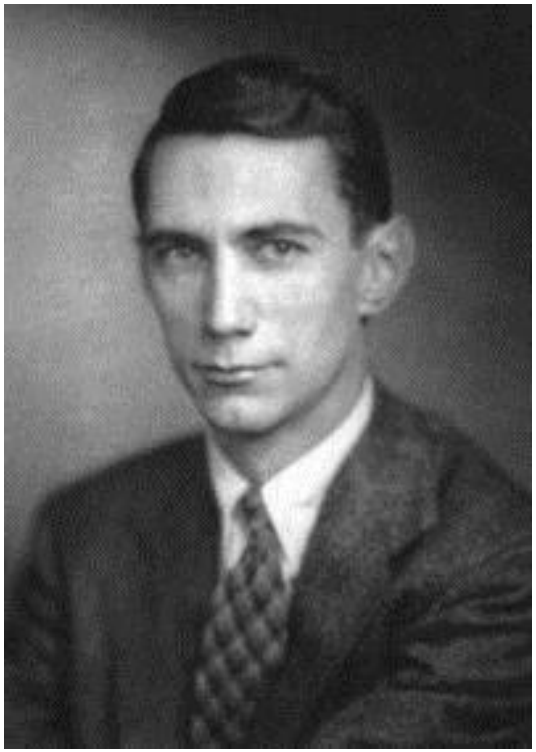
Integrating { High volume Heterogeneous Data } for easy consumption by doctors

Examples of Integrative Reporting

- Subspecialist consults
- Mike Laposata's Diagnostic Management Teams
- Genetic Counselors
  - Bayesian integration of multiple data points
  - Discussion with patient for further integration

Could Integrative Diagnostics be Automated?

Analogy: Information Theory



- Compression (reducing data to its essence)
- Error correction (managing redundancy)
- Channel capacity (don't overload the transmission line)
- Standardize messages and manage the transmission

Not Part of Information Theory (but really important to us)

- Importance of the message
  - Temporal/Urgency
  - Actionable-ness

Explanatory Power of a Theory

= Ability to explain what's going on

= "Predictive power"

Two Main Categories of Theories in Laboratory Diagnostics

- A particular disease is present/absent
  - Screening
  - Initial diagnosis (confirmation)

- A disease process has changed (better/worse)
  - Monitoring

Theory 1: Screening/Diagnosis

- Always some pretest probability

- Key question: How much does this test result push that probability up or down?
  - Key subquestion: Does this test result push me over an action threshold?

Theory 1: Screening/Diagnosis

- Likelihood ratio
  - Troponin I (strong LR)
  - Lyme serology (weak LR)

- Allows Baysian calculation

$$\text{Posttest odds} = \text{Pretest odds} * LR_{\text{1st test}} * LR_{\text{2nd test}}$$

Theory 1: Screening/Diagnosis

•Problem: Need to know distributions of results for "similar" patients who are:

- Normal/healthy
- Early stage disease

Theory 2: Monitoring Disease

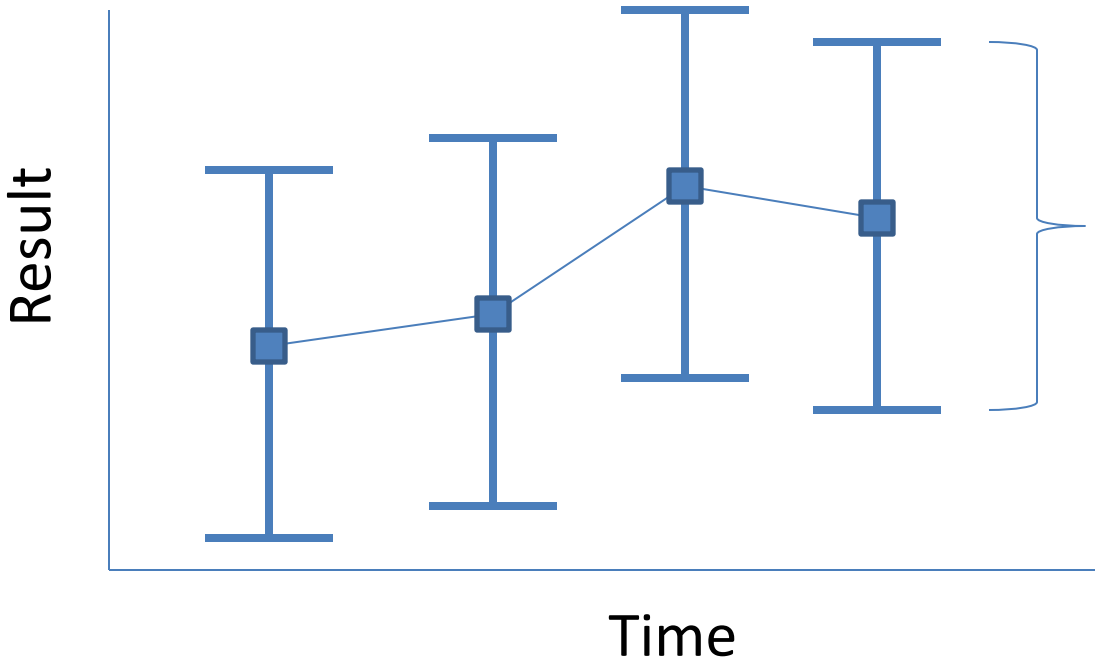
- Is the physiologic process changing?
- How fast/how much?
- Measuring treatment response
  - What is the “typical” response?

Theory 2: Monitoring Disease

- Lab tests as surrogates

- Mathematical relationship to underlying disease progression?
  - Linear
  - Nonlinear
  - Threshold

Representing Uncertainty



Sum of:
- Pre-analytic variation
- Analytic variation
- Within-subject biological variation

"Reference change values" From:

Biological Variation: From Principles to Practice

Callum Fraser, AACC Press, 2001

Proposal

- Diagnostic settings: Report all results as LRs
- Monitoring settings: Report all results with RCVs
- All settings: Mathematically integrate all results with patient's other data

This should allow…

- Compression
  - Reduce lab results to mathematical entities
- Error correction
  - Which confirmatory tests needed?
- Channel capacity
  - Don’t overload doctors’ cognitive capacity

How Can We Get There?

- Better data on populations
  - Normal & diseased comparisons
  - “Patients like me”
- Better data on test performance
  - Preanalytic/analytic/intraindividual variation
- Access to clinical context
- Need tools for integrating, presenting lab data

ARUP® LABORATORIES

UNIVERSITY OF UTAH
SCHOOL OF MEDICINE | Department of Pathology