

# When the Lab Stops Reporting and Starts Forecasting







# Information Overload is Upon Us in Contemporary Healthcare

- Interpreting a lab value is hard enough.
- What if the target observation (that **green** dot) is a biologically reproducible signature in a 60-dimensional space?
  - Two obvious eventualities result:
    - The observation will likely be missed
    - The observation, if it is to be detected, will require data analytics in a seamless decision support fashion

# The Uncomfortable Truth: Labs Drive Decisions, but Reports Lag Behind

- Labs are the “truth engine” of medicine—but outputs are still transactional: result, reference range, maybe a flag.
- Clinicians already try to infer prognosis using *scattered* info: progress notes, imaging, staging, prior trends, genomics, social factors; reports are divided into silos based on laboratory unit, and not aggregated into a unified report that informs of the *biological potential of the disease at hand*.

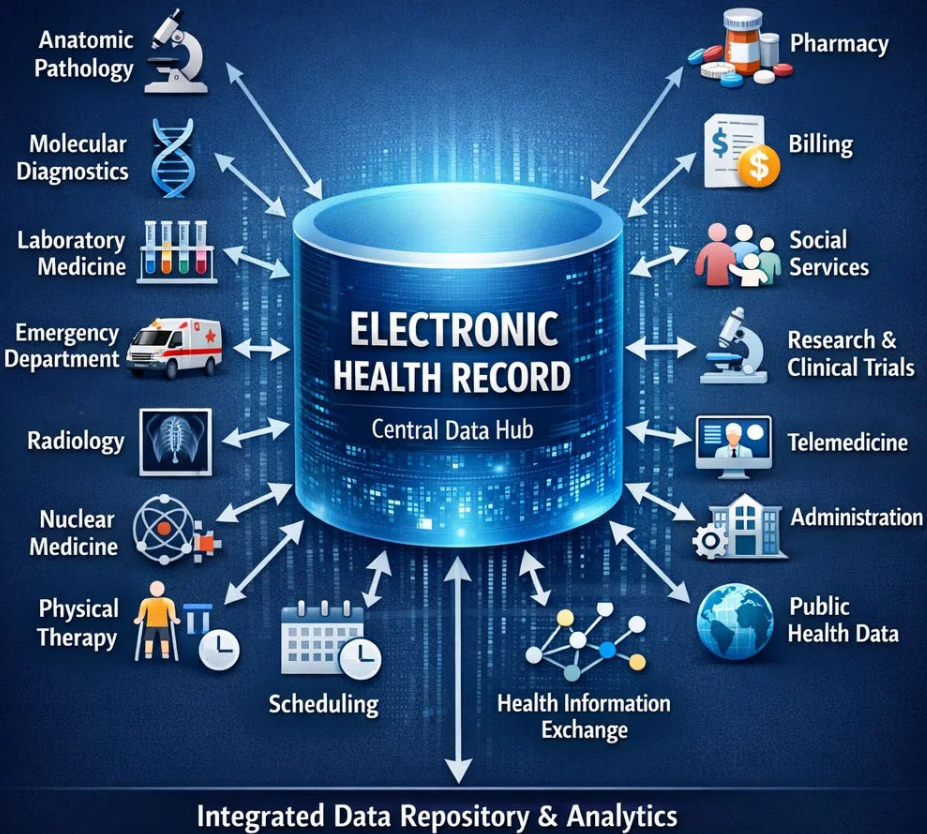
# Several Inconvenient Truths....

- ~70% of medical decisions are based on laboratory and anatomical pathology data
- >99% of medical decisions that involve selection of biological agents for treatment of malignancy are based on (or should be) molecular laboratory data.
- However, molecular data is **multi-dimensional**, and so too is the analytics data extracted from anatomic pathology.
- Additionally, predictive models can be greatly improved by adding additional classes and types of data (multiplexed data sets).

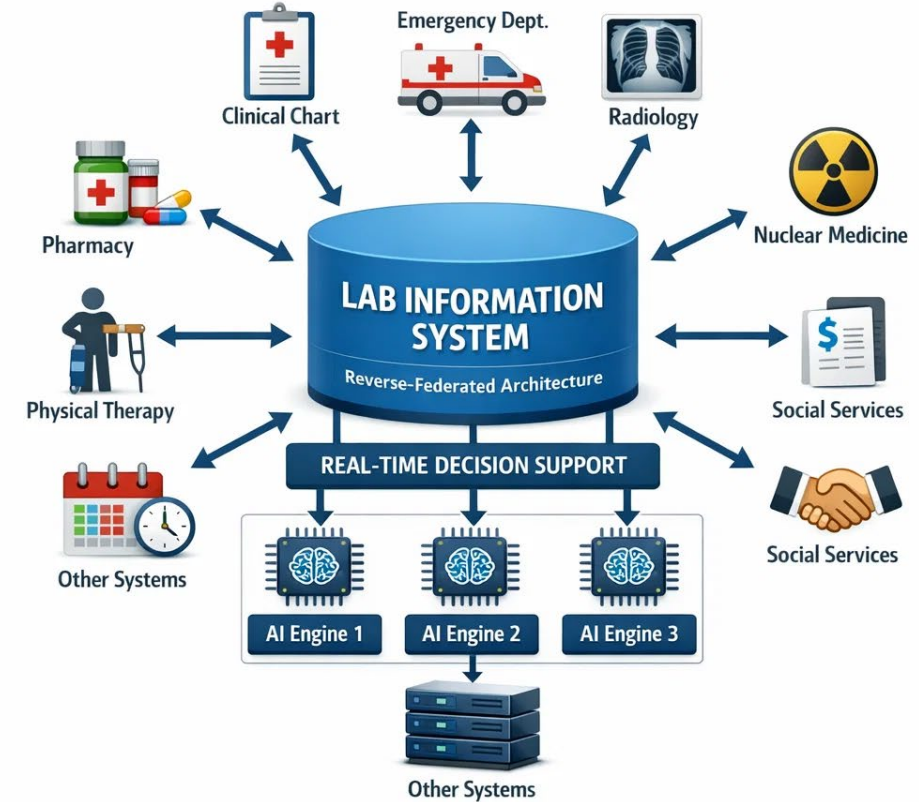
*But...*

Laboratories typically don't have access to the full repertoire of the overall electronic health record. This needs to change

## Enterprise-Wide Federated Data Architecture



## Laboratory-Centered Reverse-Federated Data Architecture



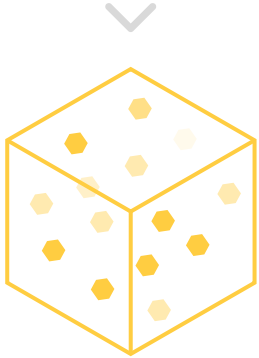
It is important to recognize that the practice of laboratory medicine, anatomic pathology, and molecular diagnostics & genetics is predicated upon interpretation of clinical observations and data types.

As such, the lab becomes a **consumer** of enterprise data and not merely a **data source**.

**Reverse Federation** allows the lab to receive the needed **ephemeral** snapshot of all clinical observations to allow for multiplexed computational analysis and prediction of outcome.

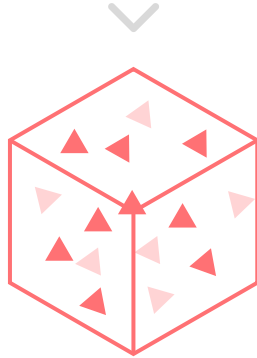
## AP Data

Whole slide imaging and sub-visual data



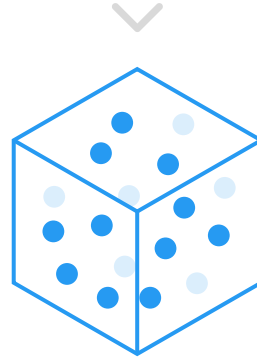
## Chemistry Data

Time series analytes.



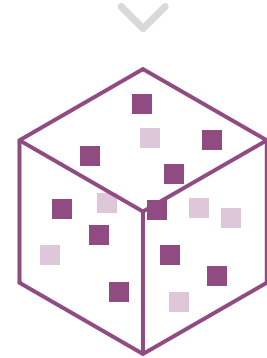
## Hematology Data

Including Flow Cytometry and even list mode data




## Multiple Clinical Data Sources

The remainder of the clinical chart



Data Lake Ingestion



# The Pathology-hosted Ephemeral Lab Analytics Data Lake

Just-in-time federated data  
is utilized to provide  
multiplexed data analytics.

# The Vision: The Lab Report Becomes a Personalized & Integrated Predictor of *Biological Potential of Disease*

- A “next-gen lab report” that combines:
  - Lab values + longitudinal trends
  - Genomics (tumor + germline, where available)
  - Pathology synoptics
  - Radiology impressions
  - Clinical context (H&P, progress notes)
- Output is not just diagnostic. It’s also predictive:
  - “High likelihood of metastasis within 6–12 months if untreated”
  - “Expected response probability to therapy A vs B”
  - “Recommended next-step actions / care pathway triggers”

# The Art of the Possible: The LIS as an Intelligence Hub

- Today: LIS = sample tracking & results distribution
- Tomorrow: LIS + ML = an inference engine
- Ingest results (chemistry, heme, micro, path, genomics)
- Ingest clinical context (notes, radiology, meds, diagnoses, vitals)
- Run models (risk, trajectory, phenotype)
- Deliver “report / forecast / next steps” to EHR, portal, care teams

# Case Study: A Cacophony of Individually Ordered Tests Becomes an Early Warning Tool for Malignancy and Risk of Aggressive Tumor Behavior

- A 58-year-old with a newly diagnosed malignancy
- Pathology: intermediate grade, positive margins with lymphovascular invasion
- Genomics: mutation pattern suggestive of aggressive biology
- Radiology: subtle node mentioned as “indeterminate”
- Lab trends: inflammatory markers, LDH, subtle anemia progression, added encoded information in time series data of serial lab values over the past six months
- Clinical notes: weight loss, pain pattern, ECOG change

## SURGICAL PATHOLOGY REPORT

**Patient Name:** John Doe      **Date of Service:** 01/10/2022  
**Medical Record Number:** 12345678      **Physician:** Dr. Smith

**SPECIMEN:** Liver, Tumor Resection

**DIAGNOSIS:** **Cholangiocarcinoma** (Intrahepatic)

- Moderately differentiated adenocarcinoma.
- Tumor size: 3.5 cm in greatest dimension.
- Lymphovascular invasion: Present.
- Perineural invasion: Present.
- Margins: Negative for malignancy.

### IMMUNOHISTOCHEMISTRY:

- CK7: Positive
- CK19: Positive
- CEA: Focal Positive
- CA 19-9: Positive
- p53: Wild Type
- Ki-67: 20%

### MOLECULAR STUDIES:

- **Next-Generation Sequencing (NGS) Panel:**
  - **FGFR2:** Fusion Detected (FGFR2-BICC1)
  - **IDH1:** R132C Mutation
  - **KRAS:** Wild Type
  - **TP53:** Wild Type
  - **Microsatellite Instability (MSI):** Stable
  - **PD-L1 Expression:** Negative (CPS < 1%)

**Pathologist:** Dr. Karen Lee

**Report Date:** 01/12/2022

Laboratory and Anatomic Pathology Reporting, in the setting of having access to federated data and multiplexed analytics with advanced (e.g. Hidden Markov Model) prediction, will tell a complete story, and not merely serve up discrete pieces of the diagnostic puzzle.

1. Reactive confirmation gives way to proactive prediction.

2. The laboratory becomes the singularly most important point for initiation of care.

3. Advanced forecasting tools allows the earliest possible intervention.

## Surgical Pathology Report

**Patient Name:** Jane Doe  
**DOB:** 05/12/1965  
**Specimen #:** BX-2023-456

**Medical Record #:** 12345678  
**DOB:** 05/12/1965

### DIAGNOSIS

**Cholangiocarcinoma** (Bile Duct Cancer)

**Histologic Grade:** Moderately Differentiated (Grade 2)

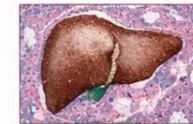
**Staging:** T2 N1 M0

### MOLECULAR FINDINGS

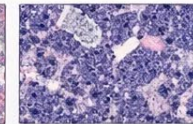
- ▶ *Whole Genome Sequencing Analysis*
- ▶ **Mutations Identified:** **KRAS** (G12D), **TP53** (R248W), **FGFR2 Fusion**
- ▶ *High-Dimensional Multiplex Data Integration*

### PROGNOSTIC INSIGHTS

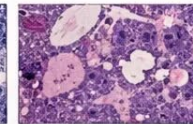
- ▶ **Estimated Time to Metastasis:** 8-12 Months
- ▶ *Predicted Sites of Metastasis*



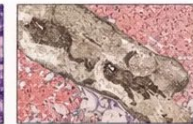
Liver



Lung



Lymph Nodes



Bone

### CLINICAL TRIAL OPPORTUNITIES

Trial ID	Target Therapy	Eligibility	Odds Ratio of Success
CT-101	<b>FGFR2 Inhibitor</b>	Eligible	<b>72%</b>
TRK-202	<b>KRAS Inhibitor</b>	Eligible	<b>58%</b>
P53-305	<b>P53 Reactivator</b>	Eligible	<b>45%</b>
IMM-410	Immunotherapy	Eligible	<b>33%</b>

### COMMENTS

HMM Analysis suggests earliest metastasis to liver. Recommend prompt consideration of **FGFR2-targeted** clinical trial CT-101 due to highest success probability.

# Approaches

## Old World

- Labs ordered individually
- Labs results reported individually
- Each specialist sees a slice of the overall diagnostic reality
- The report doesn't connect all the pieces
- Encoded data, which is often prognostic, is unavailable and left on the table, and therefore
- No biological assessment of potential of malignancy to metastasize

## New World

- The reimagined lab report includes new sections:
  - Prognostic Insights:
    - Detection of elevated near-term metastatic progression risk
    - Predicted sites of metastasis
  - Clinical trials opportunities
  - Expected clinical trials odds ratios for a successful response, based on hidden Markov models extracted from pilot literature and public datasets, when available
  - Detailed biological potential of malignancy assessments (e.g.):
    - “High-risk trajectory: predicted progression window 6–9 months without intensification.”
    - “Recommend: staging PET/CT within 14 days; oncology follow-up within 7 days; consider regimen B; enroll in surveillance pathway.”

# How Does One Make use of Such AI Tools Safe?

- Models don't replace clinicians; they prioritize attention and reduce missed signals.
- Provide evidence trace:
  - which features drove the forecast (e.g., pathology grade group, ctDNA, LDH, radiology term "indeterminate node," trend in anemia)
- Provide confidence + calibration:
  - "Model calibrated on N patients, performance AUC/Brier, subgroup checks"
- Include human-in-the-loop sign-off for high-impact statements.

→ *The goal isn't to automate decisions. It's to automate situational awareness.*

# Reports Are No Longer Static: They Become Living Documents

- Reports are updated as new labs and new notes arrive.
- Reports becomes registry entries and a care pathway triggers, including:
  - alerts
  - follow-ups
  - tests due
  - gaps-in-care
- Patient can benefit from a translated version:
  - “Here’s what we know about your cancer and what’s likely to happen next.”

# Business And Societal Wins

- Better Outcomes & Sustainable Labs
- Fewer late-stage admissions via early identification
- Better alignment with value-based care:
  - reduced total cost of care
  - improved quality metrics
  - better risk adjustment accuracy because diagnosis is earlier and documented
- For labs:
  - shift from cost-per-test to value-per-insight
  - The lab becomes a predictive service line

***If the lab can help prevent ICU stays, then it no longer need be seen as a cost center.***

# So, What Does This All Mean, In Actions?

- If you're a laboratorian: don't just deliver results: deliver foresight in the form of complete diagnostic reports that span lab sections.
- If you're a health system leader: fund the lab as an analytics **partner** and not as a cost center.
- If you're a vendor: make the report programmable, **explainable**, and safe.

*Clinical Lab2.0 is creating tools to be a partner in the pursuit of these goals.*