



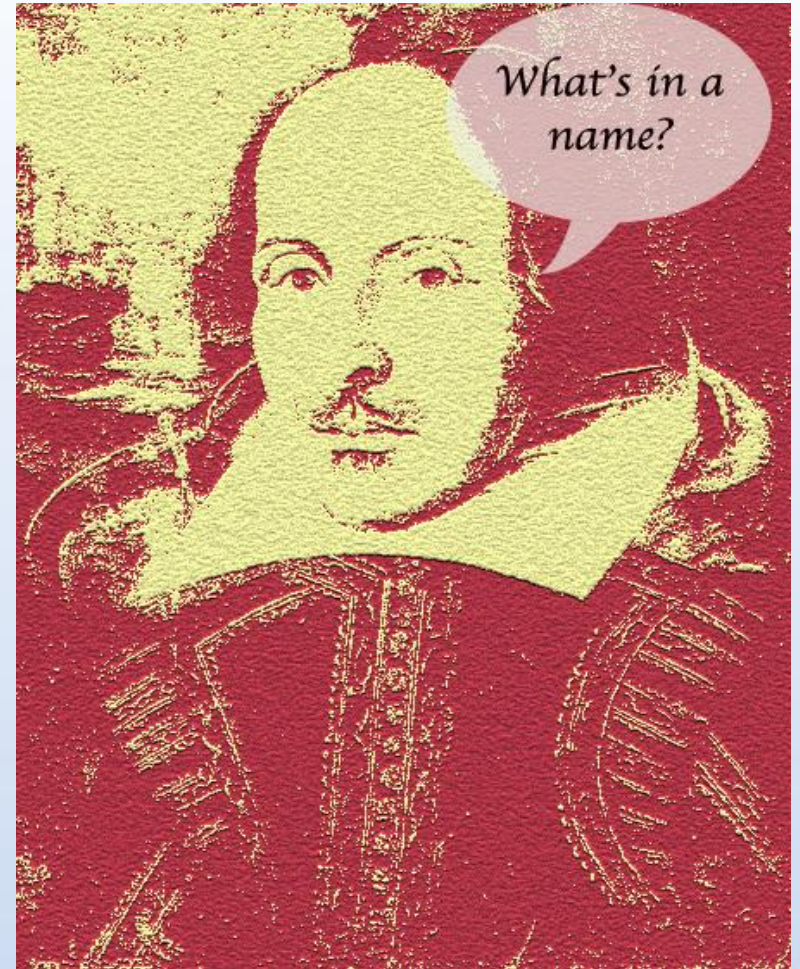
Geisinger

**Leveraging Informatics to Improve  
Health Outcomes and Value**

**Marc S. Williams, MD**  
**Director, Genomic Medicine Institute**  
**Geisinger Health System Danville, PA**

# Topic Perspective

Genomic Medicine  
Personalized Medicine  
Individualized Medicine  
Precision Medicine



# Genomic Medicine

- Includes
  - Traditional single gene disorders (genetics)
  - Analysis of the whole genome (genomics)
  - Analysis of subsets of the whole genome
    - Exome sequencing
    - Pharmacogenomics
  - Family History

# Personalized Medicine-Definition

“...use of information and data from a patient’s genotype, or level of gene expression to stratify disease, select a medication, provide a therapy, or initiate a preventative measure that is particularly suited to that patient at the time of administration”

– Wikipedia

# Genomic Medicine ≠ Personalized Medicine

“Personalized medicine is the practice of clinical decision-making such that the decisions made maximize the outcomes that the patient most cares about and minimizes those that the patient fears the most, on the basis of as much knowledge about the individual’s state as is available.”

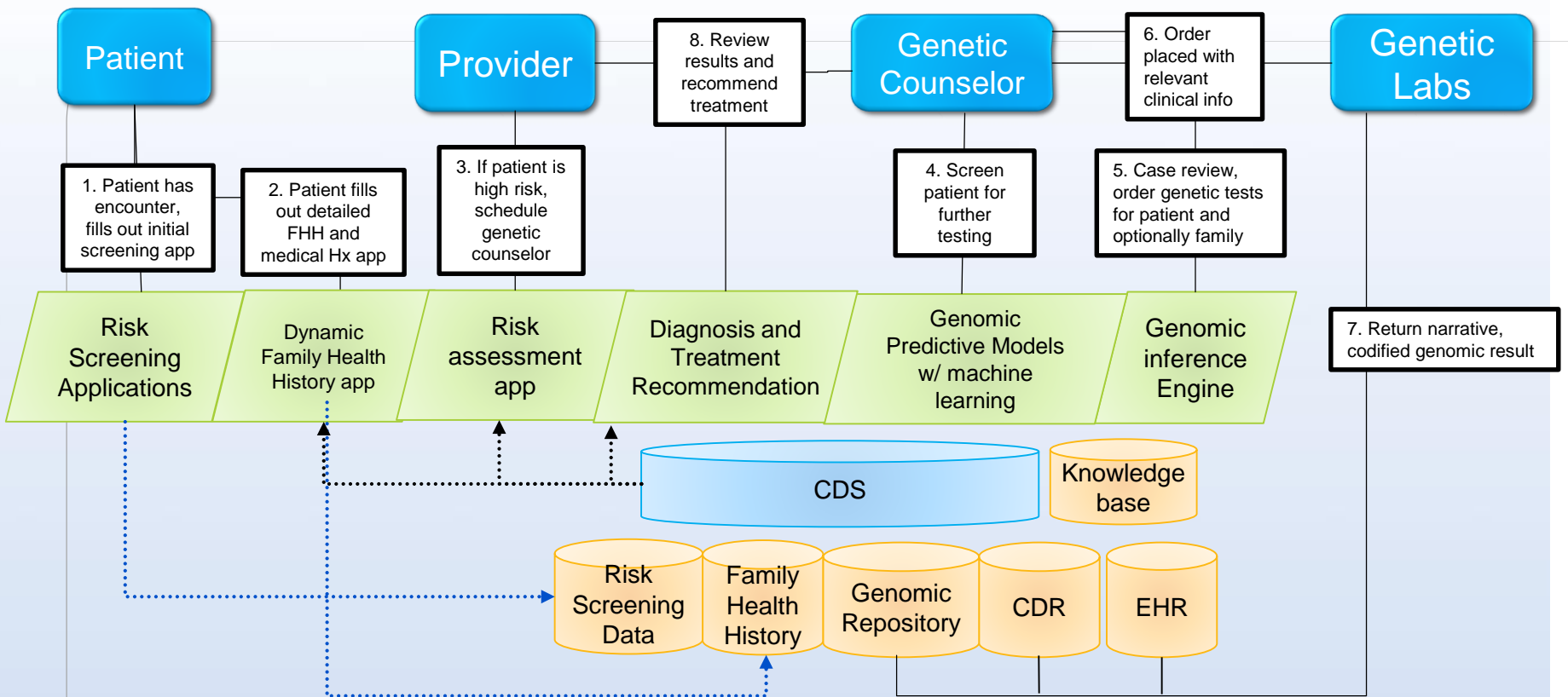
# Personalized vs. Precision Medicine

- Clinicians practice personalized medicine (and always have)
- Currently--Intuitive medicine
  - Care for conditions that can be diagnosed only by their symptoms and only treated with therapies whose efficacy is uncertain and watching for empiric response.
  - Empiric 'trial and error'
- Future—Precision medicine
  - The provision of care for diseases that can be precisely diagnosed, whose causes are understood, and which consequently can be treated with rules-based therapies that are predictably effective.
  - Expect genomics to play a key role in this





# GenomeFIRST™ A NEW PARADIGM FOR RETURN OF GENOMIC RESULTS



## The Current Approach—'Phenome First' Ideal

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- GHS Biorepository started in 2007
  - Followed extensive consultation with GHS patients and other stakeholders that informed design of project
  - Defined as Community Health Initiative as opposed to biorepository
- Participants sign broad consent to combine EHR data (prospective, de-identified) and biospecimens
- Consent includes the ability to re-contact participants for future projects and communicate medically actionable results
- Exome sequencing on participants (~53,000)

# GenomeFIRST™

**The prompt for the clinical encounter is the DNA variant**

# GenomeFIRST™ Return of Results

- 250,000 Geisinger Patients Will Have Their Exomes Sequenced.
- We will Look For Medically Actionable Results In That Data And Then Return Results To Patients And Providers.
- We will support the patients and providers in the follow-up to the results and long term management planning.
- We will be Operationalizing A Scalable Genomic Return Of Results Infrastructure In A Large Integrated Healthcare System

# GenomicFIRST™ Return of Results

## The Geisinger 76 (G76)

- Focus on 27 conditions (76 genes)
- Builds on the ACMG Incidental Findings List (published 2013)
- Cancer predisposition (e.g. *BRCA1* and *BRCA2*)
- Cardiovascular disease (e.g. FH)
- Malignant Hyperthermia
- Hereditary Hemorrhagic Telangiectasia
- Ornithine Transcarbamylase (OTC) deficiency

# Three Most Prevalent Conditions Half of those Returned

GENOMIC CONDITION	POPULATION PREVALENCE	CLINICAL RISK	DISEASE-ALTERING INTERVENTION
Familial Hypercholesterolemia ( <i>LDLR, APOB, PCSK9</i> )	1 in 175	Early-onset Coronary Artery Disease and Stroke	Targeted screening and aggressive medical management
Hereditary Breast and Ovarian Cancer Syndrome ( <i>BRCA1, BRCA2</i> )	1 in 400	Early-onset Breast, Ovarian, and Prostate Cancers	Targeted screening with prophylactic medical and surgical intervention
Lynch Syndrome ( <i>MLH1, MSH2, MSH6, PMS2</i> )	1 in 440	Early-onset Colon and Uterine Cancers	Targeted screening and management of pre-cancerous changes
<b>TOTAL</b>	<b>&gt; 1 in 100</b>	<b>Multiple Cancers and Cardiovascular Diseases</b>	<b>Life-saving screening and intervention before development of disease</b>

**Secondary or Incidental Finding of a  
PATHOGENIC/LIKELY PATHOGENIC VARIANT**

**GENE SPECIFIC EVALUATION  
Including history, exam, testing, consultation**

**DIAGNOSIS OF GENOMIC SYNDROME  
WITH TESTING AND INITIAL EVALUATION  
Both Genotype and Phenotype Present**

**GROUP 1  
Existing  
Genomic  
Syndrome  
Diagnosis  
Confirmed**

Previous  
genotype and  
phenotype  
documented

**GROUP 2  
Unifying  
Genomic  
Syndrome  
Diagnosis**

Previously  
documented  
phenotype and  
new genotype

**GROUP 3  
New  
Genomic  
Syndrome  
Diagnosis  
Achieved**

Sub-clinical  
phenotype  
revealed thru  
evaluation

**NO DIAGNOSIS OF GENOMIC  
SYNDROME WHEN TESTED  
Genotype without Phenotype**

**GROUP 4  
No  
Genomic  
Syndrome  
Diagnosis  
Achieved  
Initially**

Phenotype  
Emerges over  
time

**GROUP 5  
No  
Genomic  
Syndrome  
Diagnosis  
Achieved  
Initially**

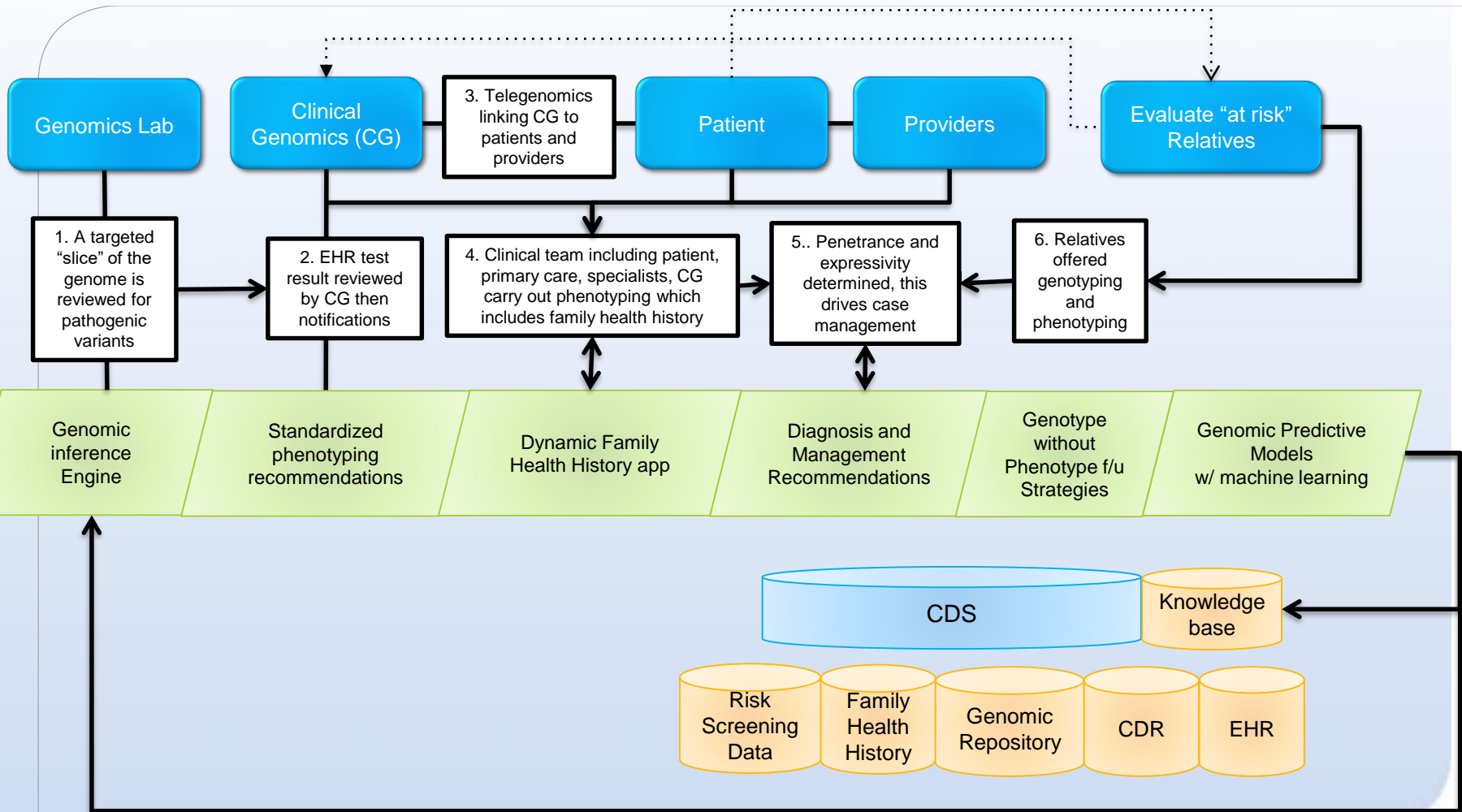
Phenotype  
Does Not  
Emerge

**GENOMIC SYNDROME DIAGNOSED  
Both Genotype and Phenotype**

**No  
Genomic  
Syndrome**



# Geisinger GenomeFIRST™ Clinical Workflow



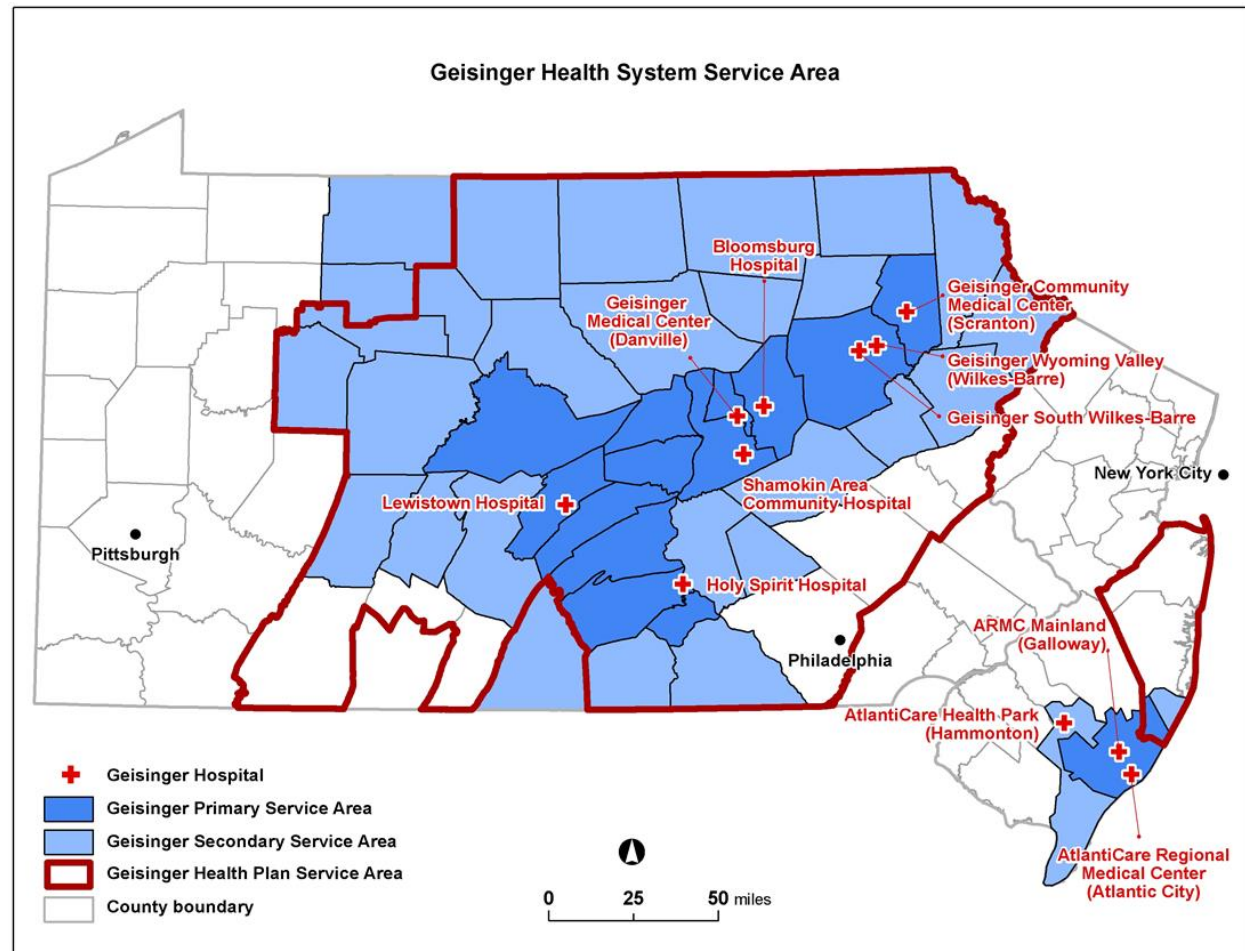
# Implementation Barriers

- System leadership
  - Genomic medicine is represented in both the system and research strategic plans
- Clinicians
  - Presentations at system-wide and department level business meetings and conferences
  - Identifying clinician champions in relevant areas
  - Take advantage of existing infrastructure
    - Multidisciplinary hereditary cancer clinics
    - Lipid Clinic
- Education and support for providers and patients
  - Goals courses (CME available)
  - Provider and patient facing genome reports
  - Genomic Medicine Consultants
- Informatics systems

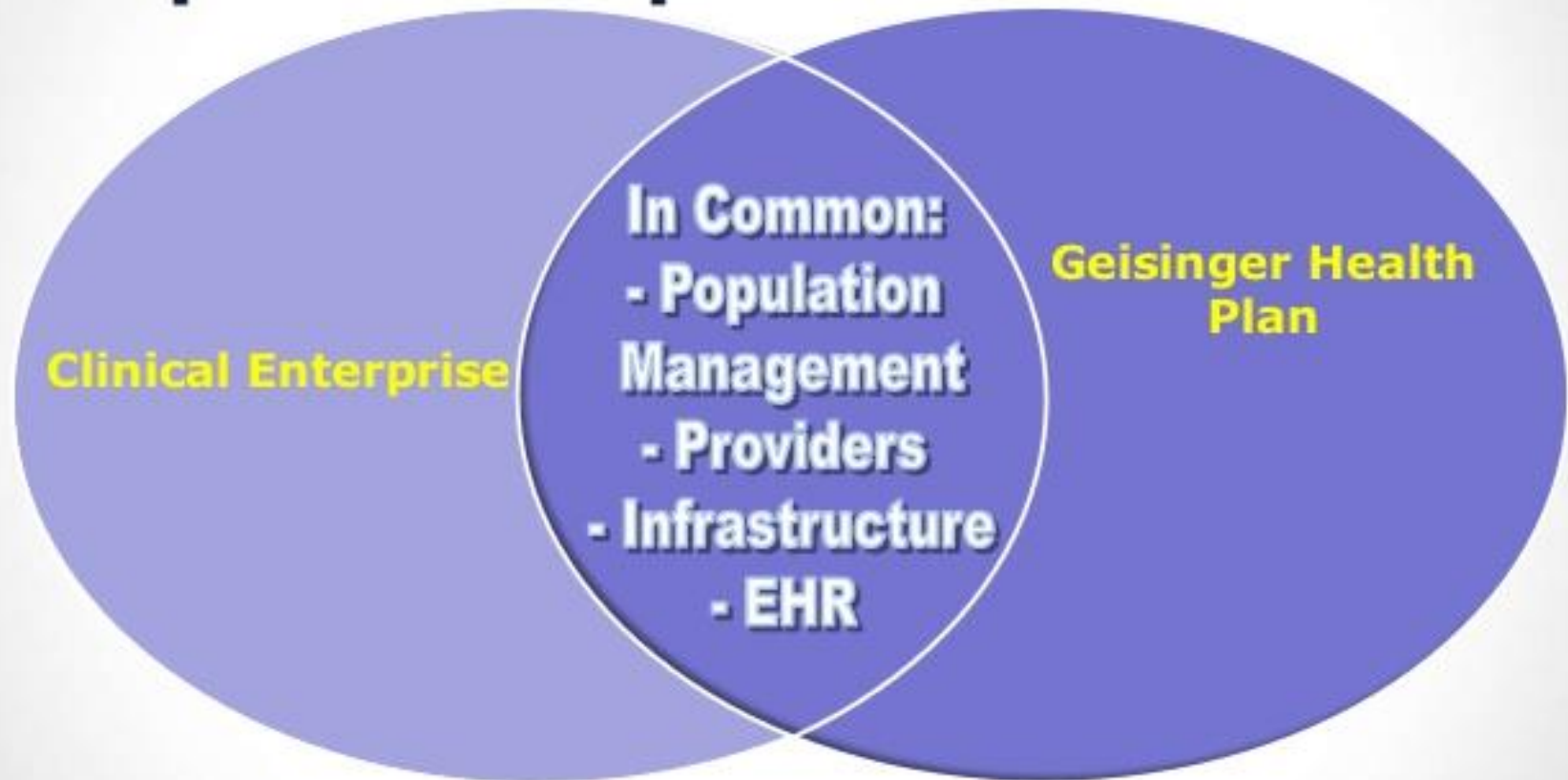
# Measuring Value

- Define outcomes for GenomeFIRST program
  - Health Outcomes
    - Process
    - Intermediate
    - Disease/Health
  - Patient-Centered Outcomes
    - Satisfaction
    - Engagement
    - Information
    - Access
    - Self-assessed well being
  - System Outcomes
    - Costs incurred/avoided
    - Utilization
    - Patient experience
    - Visibility/reputation

# Value from the Health System Perspective



# The Sweet Spot: Our realm of partnership and innovation



*Aligned objectives for the greatest impact*

| 5

# Value: Genomics over the Lifespan

## Advantages

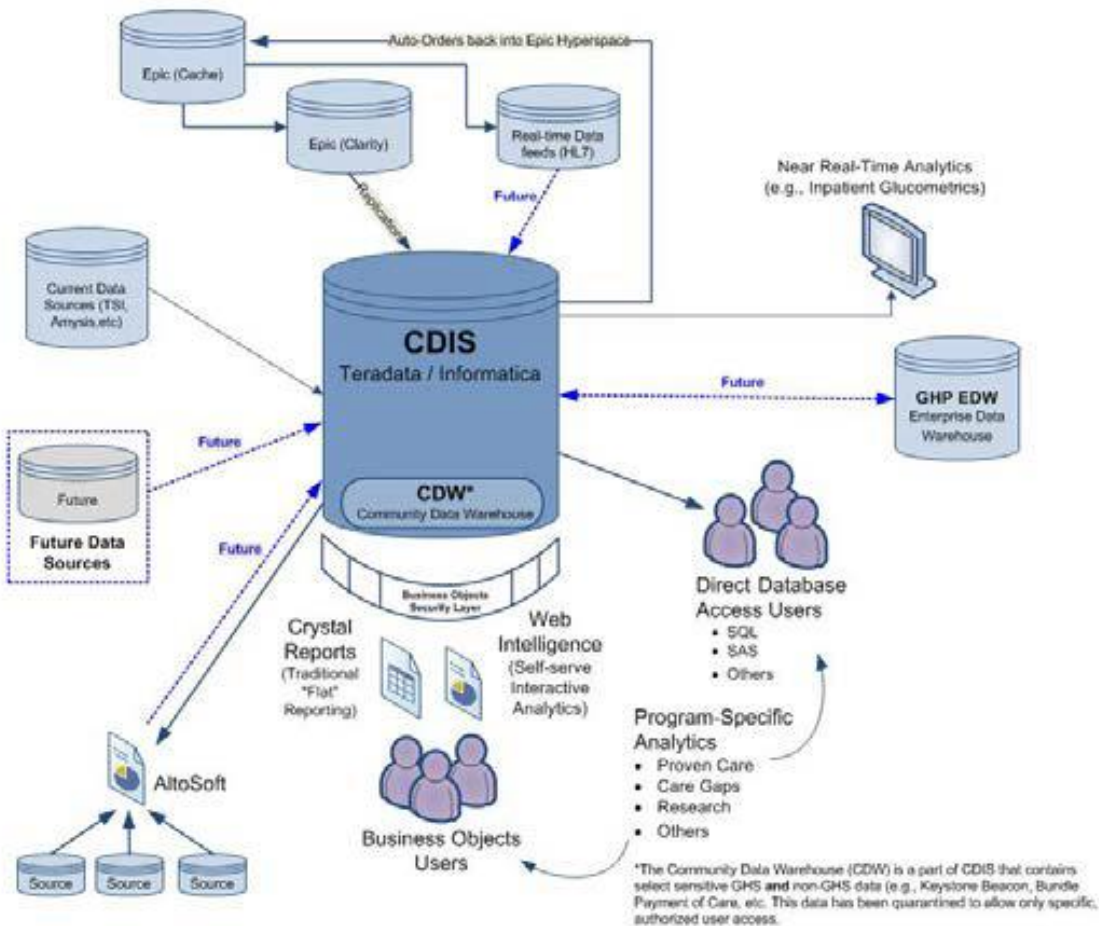
- Cost spread out over lifetime of care
- Avoids need to repeat testing
- Information can be used as soon as it is needed
- More precise pharmacologic therapy
  - Avoid adverse events
  - Choose best tolerated most effective therapy

## Questions

- Storage of information
- Presentation of information when needed at point of care
- Information available wherever patient receives care
- Evidence of benefit (or lack thereof)
- Updating information
- Discrimination
- Health Disparities



# Storage



# Information at point of care

- Focus on passive clinical decision support
- Highlight Clinical Genome Resource (ClinGen)

# ClinGen

## The Clinical Genome Resource (ClinGen)

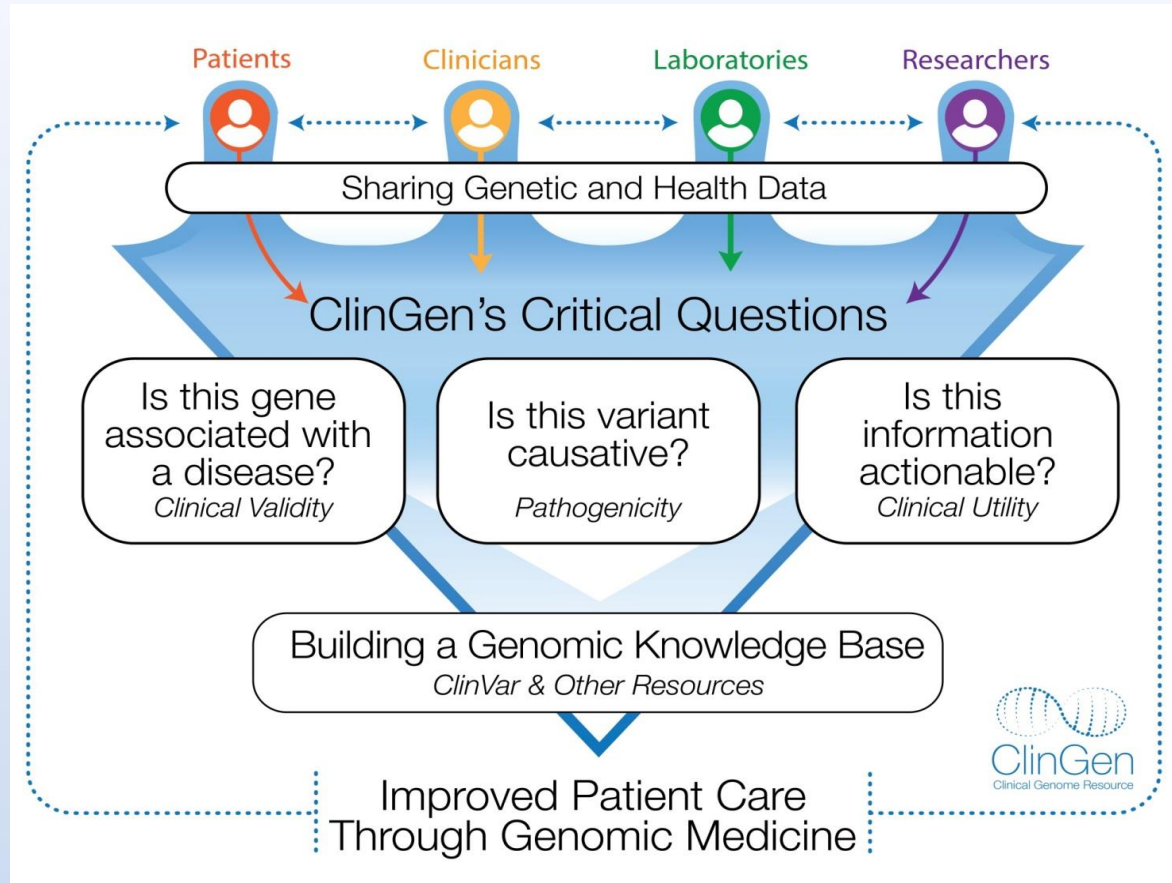
aims to create an authoritative resource that defines the clinical relevance of genes and variants for use in precision medicine and research.

## NHGRI-funded program launched Sept. 2013

- FY13-FY16 = \$28M Total Costs
- 3 U grants, working closely with NCBI's ClinVar
- Co-funding from NICHD and NCI
- > 350 researchers & clinicians from 90 institutions



# Building a genomic knowledge base to improve patient care



# Initial Solution

Welcome to ClinGen

Building a Genomic Knowledge Base to Improve Patient Care [Learn more >](#)

Seeking info about a gene or disease? Type it...

Go!

ClinGen's search feature will return relevant information from both [ClinGen Curated Resources](#) and reputable external sources.

## Sharing Data. Building Knowledge. Improving Care.

ClinGen is dedicated to building an authoritative central resource that defines the clinical relevance of genes and variants for use in precision medicine and research. [Learn more about our organization and our ongoing efforts below.](#)



### Tools & Resources

Access results of ClinGen's current curation efforts



### Working Groups

Learn more about ClinGen's various working groups



### About ClinGen

A National Institutes of Health (NIH)-funded program.

# Access to ClinGen resource from any OpenInfobutton compliant EHR system

<http://service.oib.utah.edu:8000/app/#/home>

The screenshot shows the 'OpenInfobutton Site LITE' interface. At the top, there is a navigation bar with links for 'Home', 'Custom Resources', 'Infobutton Responder', 'Resource Store', and 'System Configuration'. Below this is the 'Resource Store' section, which displays a list of five resources. Each resource card includes the OpenInfobutton logo, a name, a description, a date, and control buttons (Update, Enabled, Disabled, Test).

Resource Name	Description	Date	Control Buttons
Micromedex	Comprehensive medication knowledge base.	May 19, 2015 6:26:23 PM	Update
VisualDx	Diagnostic decision support tool coupled with a library of over 100,000 peer-reviewed skin, pathology, and radiology images.	Feb 25, 2015 6:26:16 PM	Enabled, Disabled, Test
PubMed	Largest database of indexed biomedical literature. Uses the Pubmed Clinical Queries filter, which is optimized to retrieve recent, high quality clinical studies.	Jan 13, 2015 9:09:00 PM	Enabled, Disabled, Test
Mayo Clinic patient education	Freely available patient education material from the Mayo Clinic.	Apr 2, 2015 5:54:19 PM	Enabled, Disabled, Test
MedlinePlus	Free patient education content provided by the US National Library of Medicine.	Apr 2, 2015 5:57:17 PM	Enabled, Disabled, Test



# e-Resources

The screenshot displays the HELP2 Clinical Desktop interface within an Internet Explorer browser window. The browser title is "HELP2 Clinical Desktop (Version...)" and the address bar shows "ft Internet Explorer". The application header includes "HELP2 clinical desktop" and "Menu Preferences". The main content area is titled "Patient Selection" and features a "By Demographic" tab. Below this, there are input fields for "Last Name:", "MRN:", and "DOB:". To the right, there are fields for "First Name:", "Middle Name:", "EMMI #:", "Radiology #:", "Phone #:", "SSN:", and "Sex:". "Find" and "Clear" buttons are located at the bottom right of the search area. A "Demo Mode" checkbox and a "Preferences" button are also visible in the top right of the application area.

A vertical dropdown menu is open, listing various navigation options. The "E-Resources" option is circled in red, and a blue arrow points from the "E-Resources" link in the left-hand navigation pane to this circled option in the dropdown menu.














- HELP2 clinical desktop
- Menu Preferences
- Select Patient
- Lab
- Micro
- Clinical Notes
- Radiology
- Allergies
- Medications
- Problems
- Vital Signs
- Height/Weight
- Demographics
- ECG
- Insurance
- Message Log
- Lab Order Entry
- Inpatient Reports
- Alert Review
- Web Forms
- HELP/Tandem
- Orders
- E-Resources
- Help
- Logout
- Comments
- Help2 Info

## Intermountain Medical Libraries and eResources (IHCWEB and HELP2)











### Electronic Resource Request

- [Form to request New Corporate-Wide Electronic Medical Information Resource](#)

### External resources

-  [Micromedex \(Internet version \[preferred\]\)](#)
-  [Micromedex \(Intranet version\)](#)
-  [UpToDate \(Includes Pediatric Dosage Handbook\)](#)
-  [PubMed](#)
-  [EBSCO \(Includes Cochrane & other databases\)](#)
-  [MDConsult](#)
-  [Clineguide](#)
-  [Electronic Books](#)
-  [Electronic Journals & Books \(AtoZ\)](#)
-  [National Organization for Rare Disorders \(NORD\)](#)
-  [Gene Tests](#)
-  [Genetics Home Reference](#)
-  [Merck Manual](#)

### Patient education resources

-  [Patient Education Network \(PEN\)](#)  
Links to patient education resources, including Patient Fact Sheets
-  [Patient handouts](#)
-  [Let's Talk About](#)
-  [Micromedex Care Notes](#)
-  [MDConsult patient handouts](#)
-  [Medline Plus](#)
-  [Intermountain Cancer Knowledge Base](#)
-  [Radiology Info](#)
-  [KidsHealth](#)
-  [Cancer Knowledge Base \(Educator edition\)](#)  
Account: **Intermountain**  
Username: **Cancer**  
Password: **Cancer**

### Intermountain Clinical Applications (login required)

- [CPG Viewer](#)
- [HELP2](#)
- [KAT](#)
- [KRO](#)

### Intermountain resources

- [Antibiograms](#)  
Requires an Intermountain.net or Intermountainphysician.org login
- [Clinical Genetics Institute](#)
- [Clinical Programs](#)
- [Collaborative Practice Guidelines](#)
- [Critical Care Protocols](#)
- [Emergency Department Guidelines](#)
- [Germ Watch](#)
- [LabNet](#)
- [SelectHealth Formulary](#)
- [Senior Care Resources](#)



# Add ClinGen to your e-Resources

We can create a unique link for your institution so you can add to your own e-resources collection

# InfoButtons

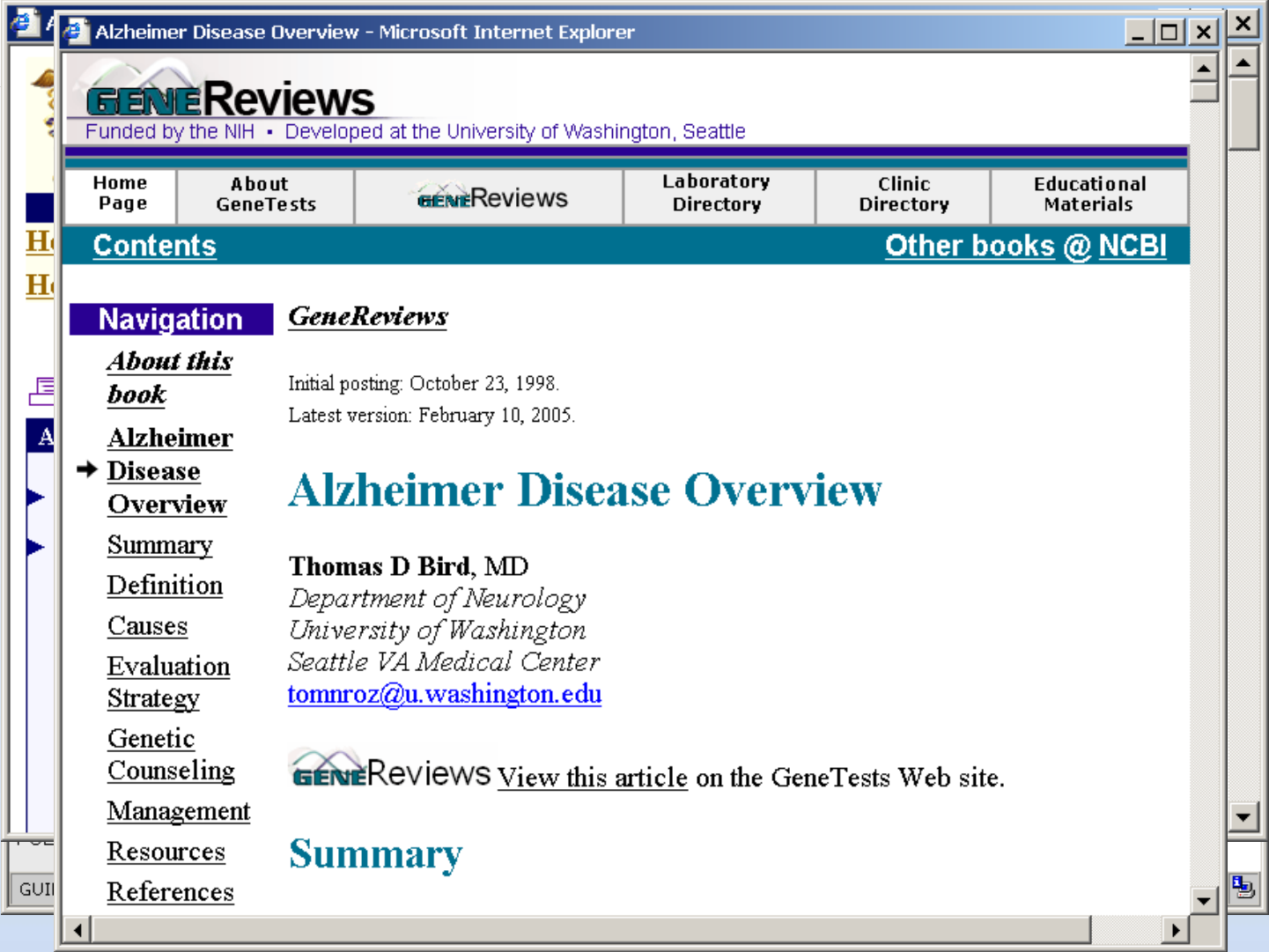
Uses a Health Data Dictionary (HDD), InfoButtons build and run queries against e-Resources based on **patient data** and **clinical context**

Take user to the most appropriate section(s) within a content collection

Minimum number of mouse clicks

# InfoButtons

	<b>Resource</b>	<b>Terminologies</b> (all use the HDD)
<b>Lab results</b>	Clineguide	LOINC codes, free-text search
<b>Medications</b>	UpToDate, Micromedex, Clineguide	RxNORM, NDC codes, free-text search
<b>Problem list</b>	UpToDate, MDConsult, Clineguide, PubMed	ICD-10-CM codes, free text search





# Future Plans

Pursuing full integration with open infobutton

Add variant level searching

Solicit input from end users (that is you!!)

- Encourage your member to go to:
  - <https://www.clinicalgenome.org/>
- Enter diseases, genes and/or medications into the search box on the home page. It may help to generate a question or questions you may want to try and answer (examples could be: does this medication have pharmacogenomics information; does this disease have a genetic cause; what diseases are associated with this gene; are there interventions for this genetic disease)
- Navigate the content collections that appear as part of the search result
- Identify suggestions for improvement of the site, the search function and/or improving your user experience

Send suggestions to Marc Williams [mswilliams1@geisinger.edu](mailto:mswilliams1@geisinger.edu), or use the contact button on the website to reach our webmaster

# Patient's information travels with them

- US healthcare system is 'dis-integrated'
- Few solutions for interoperability have been broadly implemented
- Patient is the only common actor in the system

# Patient-Centered Outcomes Research Institute

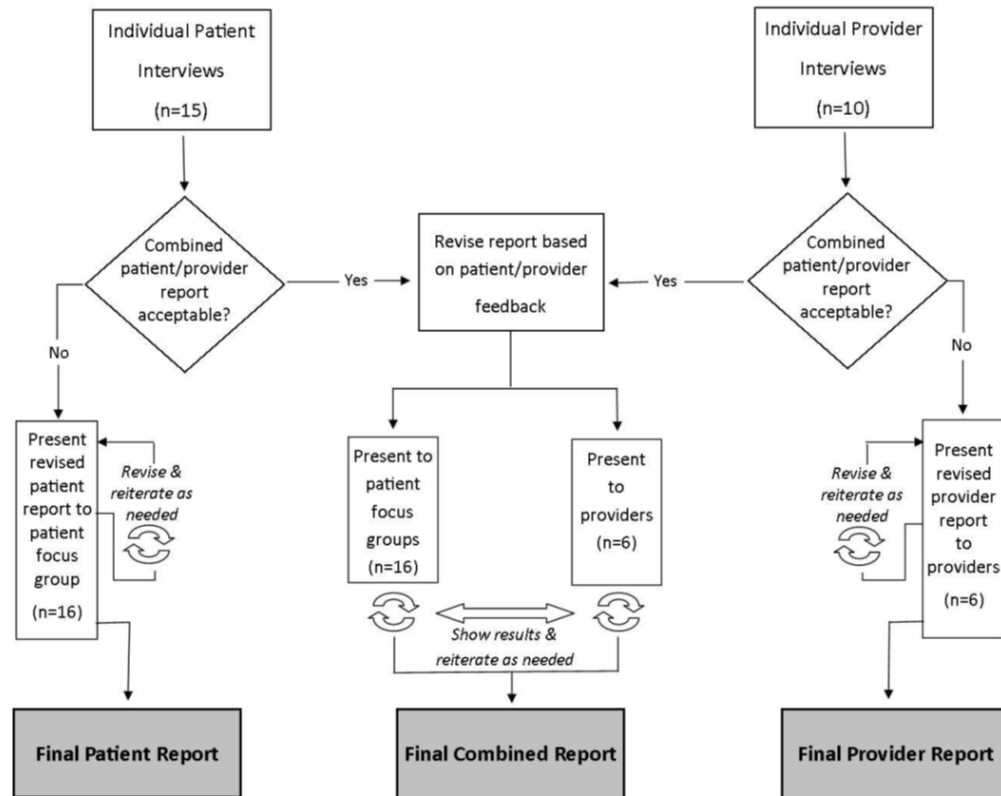
- Communication and Dissemination funding opportunity
- To design patient-facing laboratory reports
- To design a provider-facing genomic report
- To improve communication around the results of genomic tests for rare diseases



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# Development and Testing

## Genomic Test Report Development Flow Chart

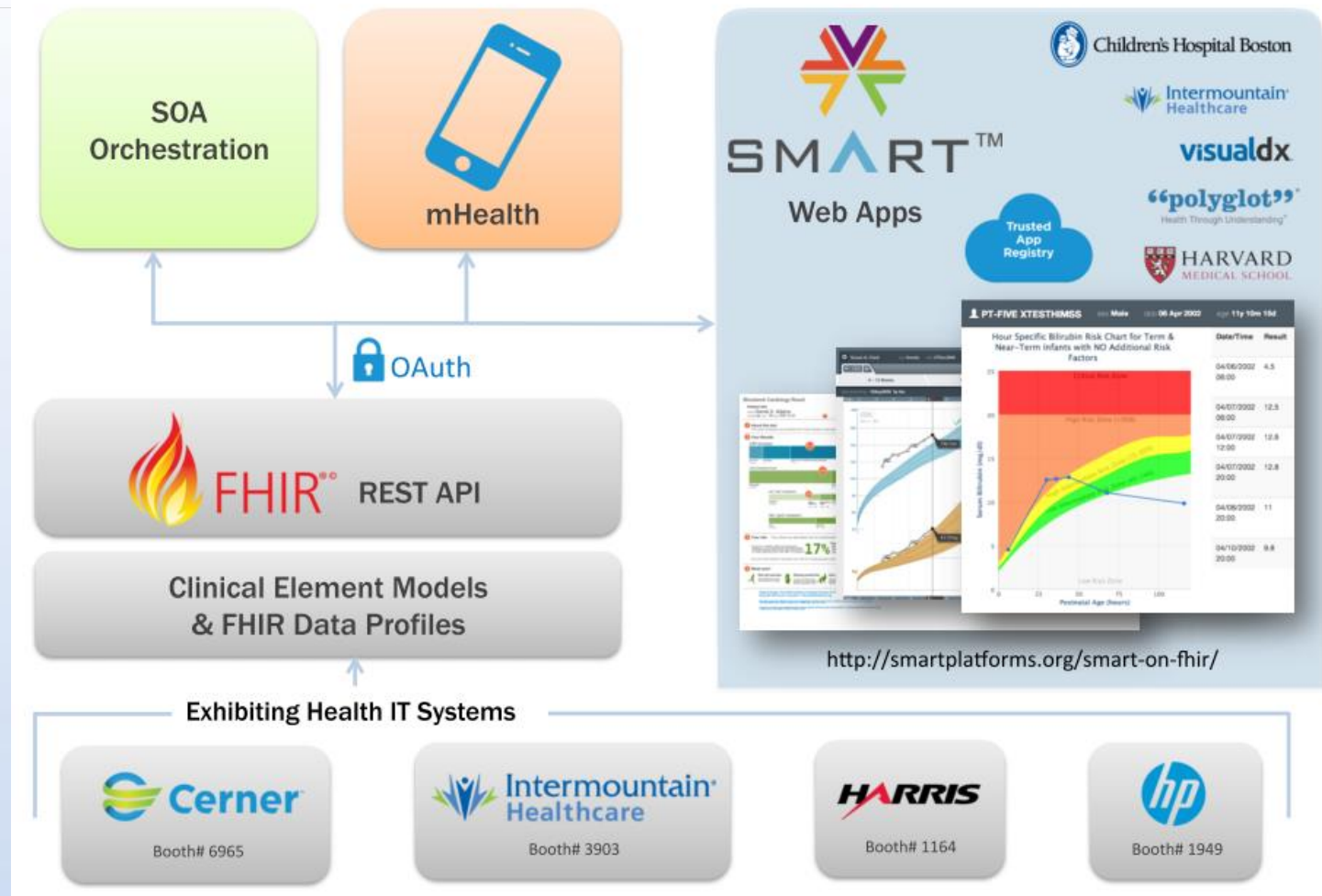


# Methods: Report Development

- Preliminary report designed by the team
- Referenced published laboratory standards
- Input from patient co-investigator
- Input from consumer education/advocacy expert
- Reviewed and revised by health literacy expert
- Provided to parents prior to in-person interviews

# Inter-APP-able: SMART Platform

## SMART on FHIR<sup>®</sup> – Open Platform Architecture



Mandl et al – details at <http://smartplatform.org>

# Compass Genome Report Primary Findings

## WHOLE GENOME SEQUENCING

Report Overview

Primary Findings **1** +

Additional Findings **1** +

Glossary & General Resources

## Report Overview

It is estimated that the human body contains 25,000 genes. We currently understand the function of only about 3,000 genes and how certain types of variants affect this function. Some genetic variants can have no effect at all, some may even be helpful, and others may be harmful. We suggest that you stay in contact with your healthcare provider and/or genetics professional at least once a year to learn if there is any new information related to your Whole Genome Sequencing test results.

### Reason for Testing

Whole genome sequencing testing was ordered to identify a possible genetic cause for your symptoms. Your symptoms were reported to include muscle weakness (myopathy), delay in physical development, and drooping of the eyelids (ptosis).

### What is included in this report?

#### Primary Findings **1**

Was at least one relevant genetic variant found? **Yes**

TTN →

No Primary Findings →

#### Additional Findings **1**

Was at least one relevant genetic variant found? **Yes**

BRCA1 →

No Additional Findings →

#### Glossary & General Resources

To learn more about genetic concepts, terms, and your diagnosis referenced throughout this report.

### Patient Information

Walter Jones

15 State Street  
APT 1  
Bloomsburg, PA 17815  
(123) 456-7890

**DOB:** 1/11/2003

**Sex:** Male

**Preferred Contact:**

Janine Jones (mother)  
1-2jones@gmail.com

**Patient Representative:**

Janine Jones (mother)

### Sample Information

**Date of Sample Collection:**  
3/20/2013

**Age at Sample Collection:**  
10 years, 2 months

**Family Samples Submitted:**  
Mother, Father

**Genetic Counselor:**  
Janet L. Williams, MS, LGC

**Ordering Clinician:**  
Marc Williams, MD  
Genomic Medicine Institute

**Referring Clinician:**  
Peter Peds, MD  
Knapper Peds

### Have Questions?

Feel free to contact Monisa Wagner with any questions pertaining to your whole genome sequencing report.

(570) 214-7941

Sequencing Labs: Complete Genomics, 2071 Stierlin Court, Mountain View, CA 94043, 560.943.2800



# Compass Genome Report Primary Findings

## WHOLE GENOME SEQUENCING

Report Overview

Primary Findings **1** -

TTN

Additional Findings **1** +

Glossary & General Resources

## Primary Findings

### What Are Primary Findings?

At this time we looked for the genes that might explain your child's symptoms. As time goes on, we may be able to look at other genes and other conditions.

### Summary of Results

A likely genetic cause for symptoms was found with a probable diagnosis of Salih Myopathy. It is important to talk with your doctor about the meaning of these results.

## Information about the TTN Gene

### What does this gene do?

The TTN gene contains instructions for your body to make a large protein that is important for the muscles of your body and heart to work. The protein is called "titin" (also known as "connectin").

### What variant(s) were found?

- TTN c.A9857G;p.K13286R (from mother)
- TTN c.G13738C;p.V4580L (from father)

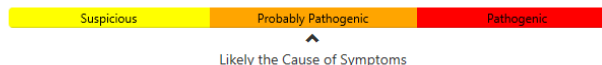
### How do variants in this gene cause health problems?

Each person has two copies of the TTN gene (one from their mother and one from their father). Some variants stop the TTN gene from working. When both copies of the TTN gene are not working, titin cannot be made correctly and patients develop symptoms.

- When a person has two non-working copies of the TTN gene, they have a condition called "Salih Myopathy"
- When a person has one normal copy of the TTN gene and one non-working copy of the TTN gene, they are said to be a "carrier". They do not have symptoms of Salih Myopathy

### Are the variants the cause of the symptoms?

These two variants are probably the cause for your symptoms because each variant is believed to stop the TTN gene from making titin. We are still learning more about this gene and this protein.



# Compass Genome Report Primary Findings

## Understanding the Diagnosis

This table summarizes the most common and medically important symptoms associated with Mowat-Wilson syndrome. There are a range of symptoms associated with this condition. Each child with Mowat-Wilson syndrome will have his or her own unique combination of the symptoms listed. Some symptoms are more common than others and are indicated this way:

### How many children with Mowat-Wilson Syndrome are expected to have this symptom?

Also, keep in mind that our understanding and management of Mowat-Wilson syndrome will change as researchers continue to study this condition. It is not possible to predict what new types of treatments and interventions will be available in the future through advances in medical science.

<b>Key</b>	Most	Some	Few	NA
------------	------	------	-----	----

Symptom:	By what age do most children with Mowat-Wilson Syndrome have this symptom?								
	At birth	1 month	3 months	6 months	1 year	3 years	6 years	10 years	15 years
ZEB2 gene mutation or deletion	Most	Most	Most	Most	Most	Most	Most	Most	Most
Developmental delay / Intellectual disability	NA	NA	Few	Some	Most	Most	Most	Most	Most
Motor developmental delay	Few	Few	Few	Most	Most	Most	Most	Most	Most
Head size is smaller than typical ("Microcephaly")	Few	Some	Some	Some	Most	Most	Most	Most	Most
Seizures	Few	Few	Few	Few	Some	Some	Some	Most	Most
Sparse hair growth	Some	Some	Some	Some	Some	Some	Some	Some	Some
Intestinal obstruction	Few	Some	Some	Some	Some	Some	Some	Some	Some
Eye movement problems (side-to-side) "Wide-based gait", an altered walking pattern where the legs are kept extended out to the sides	Few	Some	Some	Some	Some	Some	Some	Some	Some
Elbows held in flexed position	NA	NA	NA	NA	Few	Some	Some	Some	Some
Foot is flexed upwards and towards the front of the leg ("Calcaneovalgus")	Some	Some	Some	Some	Some	Some	Some	Some	Some
Gastroesophageal (GE) reflux	Some	Some	Some	Some	Some	Some	Some	Some	Some
Weight problems – low weight or a tendency to lose weight	Few	Some	Some	Some	Some	Some	Some	Some	Some
Unusual, repetitive movements and behaviors ("Stereotypies")	NA	NA	NA	Few	Few	Some	Some	Some	Some
Short stature	Few	Few	Few	Few	Few	Some	Some	Some	Some
Overly happy demeanor ("inappropriately happy affect")	NA	NA	Few	Few	Few	Few	Some	Some	Some
<b>Symptoms that can be detected only by a special test:</b>									
Electroencephalogram (EEG) – Electrical activity of the brain is measured found to be abnormally slower	Few	Few	Few	Few	Some	Some	Some	Some	Some
Echocardiogram (ECG): This test produces images of the heart's structure and may detect a heart defect ("cardiac anomaly")	Some	Some	Some	Some	Some	Some	Some	Some	Some

# Compass Genome Report Primary Findings

## Specific Issues to Discuss with Your Doctor

### Treatment options and current care

- There are no overall treatment options that change as a result of the diagnosis of Mowat-Wilson
- Some of the symptoms may be managed through various treatments

### Lifestyle changes

- Most children with this diagnosis will show delay in their motor milestones meaning that they are slow to roll over, or slow to sit and crawl and in their thinking skills.
- Most of these children will need support services into adulthood.
- Roughly one-third of children with this disease find their symptoms worsen with heat (as well as a fever or infection). Avoiding exposure to very hot conditions may be helpful.

### Support services

- Birth to Three developmental school-based program
- Speech & Language
- Physical Therapy
- Vision Aides
- Alternative Communication Devices

### Monitoring

- **Seizures:** Because the types of seizures may be different in different children, the choice of seizure medications will be specific to the type of seizure not the overall condition.
- **Anxiety or aggression** may develop in early childhood in about one-third of children with this condition, and if so, your child should be seen by a developmental neurologist/pediatrician
- **Vision problems**, including various abnormalities and decreased vision, rapid eye movement back and forth, occasionally blind or low vision from birth. These indicate the need for annual eye examinations in childhood to monitor for strabismus and the strength of the lenses (refractive errors)
- **Heart defects:** Many children will have heart defects at birth, but not all may be detected immediately. If testing shows none present, then such symptoms will not develop over time.
- **Constipation / Intestinal obstruction / Hirschsprung's Disease:** More than half of children with this diagnosis will have constipation, reflux, failure to gain weight ("thrive") or weight loss. In a few children, the nerves in the colon are not properly formed and the colon does not work.

### Additional medical specialists that may be relevant

- Developmental Neurologist/Pediatrician
- Ophthalmologist
- Cardiologist
- Pediatric Gastroenterologist

### Evaluation of relatives at risk

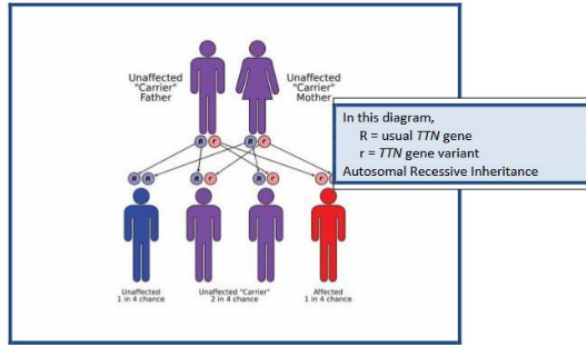
Early diagnosis of at-risk sibs by clinical examination and/or molecular genetic testing is important in order to monitor motor development and cardiac function so that treatment can be instituted early. If a fetus is diagnosed prenatally to have Salih myopathy, special considerations are needed at and following delivery since muscle weakness may manifest during the neonatal period.

# Compass Genome Report Primary

## How This Might Affect Family Members

### How is this passed on in families?

This condition is caused because you have two copies of the TTN genes that do not work correctly. One TTN gene came from Mom and one came from Dad. We know that each of you must have one copy of the TTN gene that works correctly and one copy that is not working. People who have at least one working TTN gene, do not have myopathy. Copies of the TTN gene that do not work have a change in the structure that is called a "mutation". Inheritance that is caused by two copies of non-working genes is called autosomal recessive inheritance.



### Could your siblings also have this condition?

This condition is identified early in infancy. We would know already whether or not your siblings have myopathy. Other children in the family may carry a single non-working copy of the TTN gene. They are not at risk for health problems for themselves. Any of your siblings could have testing to find out if they carry one or the other of the TTN gene changes.

### Could your children also have this condition?

You have a 1 in 4 chance or a 25% chance with each pregnancy that each child could inherit two non-working copies of the same gene. There are 3 out of 4 chances or 75% chance that each child in the future would not have this myopathy. If you are thinking about children in the future we can talk about possible testing options before or during pregnancy.

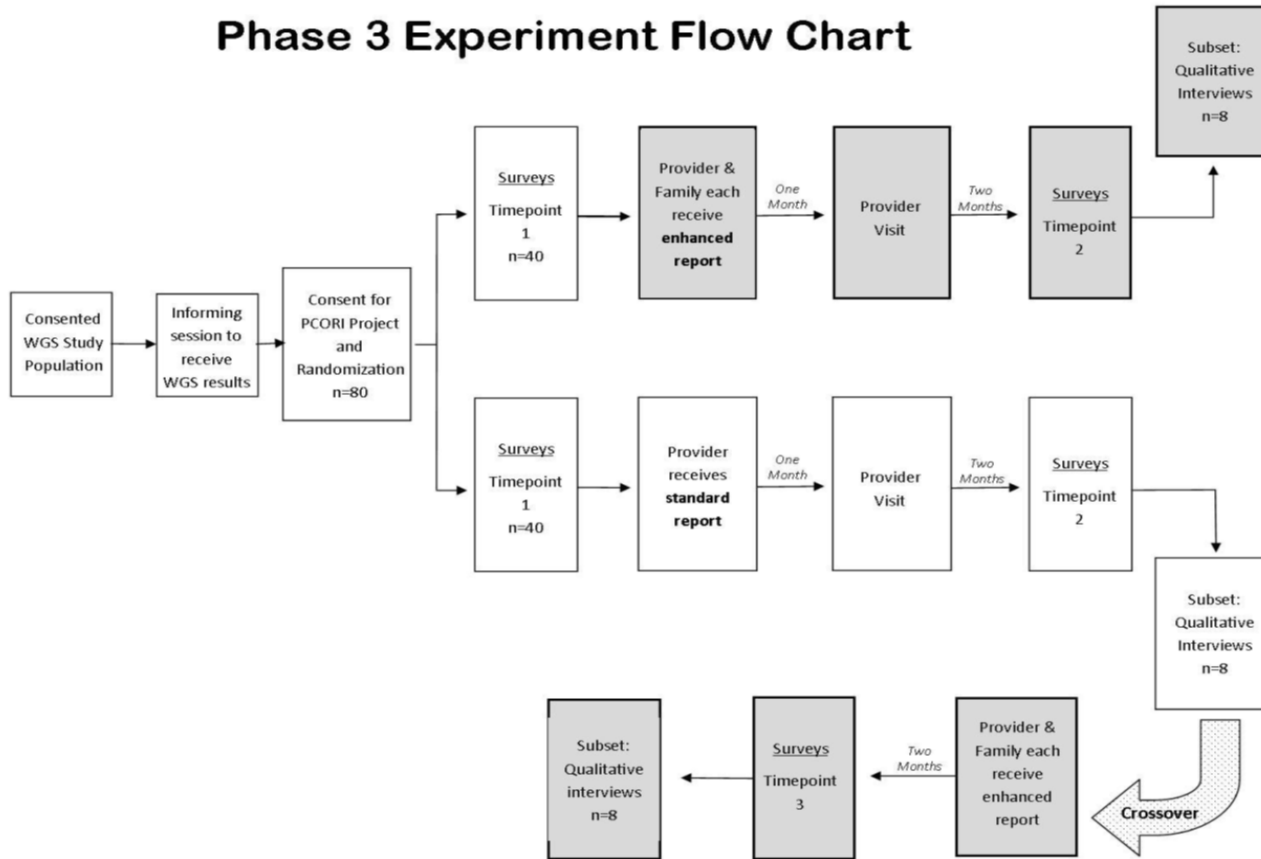
### Genetic testing for family members

## TTN Resources

- **Children's Hospital:** <https://www.childrenshospital.org/research-and-innovation/research-labs/beggs-laboratory/recent-developments/nemaline-animation>
- **Jashua Frase:** <http://www.joshuafrase.org/life-with-cnm-mtm/the-disorder.php>
- **Myopathy Support Group:** A support group that focuses on myopathy may also be helpful. <http://www.childrenscardiomyopathy.org/>

# Comparative Effectiveness Trial

## Phase 3 Experiment Flow Chart



# Conclusions

- Genomics as an emerging technology must be able to demonstrate improved value in the health care delivery setting before it will be adopted
- Implementation is complex and requires a systematic approach of engagement, education, evidence and evaluation
- Outcomes must be defined and systems built to support measurement to determine which services add value