

Existing and Emerging Information Technologies that Affect Genomic Data Sharing

Joyce A. Mitchell, PhD

Associate Vice President, Health Sciences IT

Professor and Chair, Dept of Biomedical Informatics

University of Utah, Salt Lake City, UT



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Biomedical Informatics

Genomics

- You know a lot about Genomics
 - Human Genome Project complete in 2003
 - 25,000 genes, perhaps 1,000,000 proteins
 - HapMap completed in 2005
 - More than 1 million SNPs
 - Now over 5000 genomes available online
 - Incredible information is available online
 - Public data repositories are routine

Genomics (cont)

- Almost 1900 specific genetic tests available
- 1 million SNP chip studies are routine
- GWAS studies are rapidly expanding knowledge (looking for G2P associations)
- Gene expression studies are impacting clinical care
 - Gene function can be measured and used diagnostically
- Next Generation Sequencing has arrived.
 - Avg variant file for a complete human sequence is 3.1 – 4.5 M SNPs, and about 10% more for INDELS, etc. Science 2009. 19892942

Consumer Demand for Genetics Information is *Exploding!*

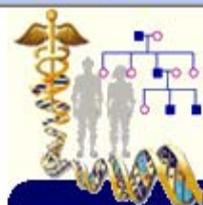


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What is the GHR? <http://ghr.nlm.nih.gov/>

- An information system focusing on the health implications of research arising from the Human Genome Project
 - Targets the *public*
 - Bridges consumer health information and bioinformatics data
 - Links to existing resources (NLM and other)



Genetics Home Reference

Your Guide to Understanding Genetic Conditions

[About](#) [Site Map](#) [Contact Us](#)

A service of the U.S. National Library of Medicine®

What's New

- ZAP70-related severe combined immunodeficiency
- 22q11.2 duplication
- Miller-Dieker syndrome
- More...

Newborn Screening

Detecting genetic disorders for early treatment

In the Spotlight

- Learning Activities
- The Genetic Information Nondiscrimination Act (GINA)
- Information Rx

Genetic Disorders A to Z and related genes and chromosomes

Genetic Conditions

The genetics of more than 450 health conditions, diseases, and syndromes.



Genes

More than 650 genes, health effects of genetic differences, and gene families.



Chromosomes

Chromosomes, mitochondrial DNA, and associated health conditions.



Concepts & Tools

for understanding human genetics

Handbook

Learn about mutations, inheritance, genetic counseling, genetic testing, genomic research, and more.



Glossary

Medical and genetics definitions.



Resources

Links to other genetics information and organizations.



Genetics Home Reference provides consumer-friendly information about the effects of genetic variations on human health.

The resources on this site should not be used as a substitute for professional medical care or advice. Users seeking information about a personal genetic disease, syndrome, or condition should consult with a qualified healthcare professional. See [How can I find a genetics professional in my area?](#) in the Handbook.

Published: November 29, 2009

[Lister Hill National Center for Biomedical Communications](#) 
[U.S. National Library of Medicine](#) , [National Institutes of Health](#) 
[Department of Health & Human Services](#) , [USA.gov](#) 

Genetics Home Reference statistics

- 500 health conditions
- 700 curated + 1800 auto-generated gene summaries
- 215 million hits per year

As of 11-2009

Direct to Consumer Genetic Testing

A huge force for changing the pace and standards for data exchange in genomic medicine.



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“It’s fun to learn about your genome.”



23andMe “Spit Party” in NYC

Fashion & Style section

The New York Times

September 12, 2008

From Mark Boguski, MD, PhD

Direct to consumer genetic tests

- 23&me <https://www.23andme.com/>
- Navigenetics <http://www.navigenetics.com>
- DecodeMe <http://www.decodeme.com/>

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[Inbox](#)

Health

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[Research Reports](#)
[Health Labs](#)

Ancestry

[Maternal Line](#)
[Paternal Line](#)
[Relative Finder](#)
[Ancestry Painting](#)
[Global Similarity](#)
[Ancestry Labs](#)

Sharing & Community

[Compare Genes](#)
[Family Inheritance](#)
[23andMe Community](#)

23andWe

[My Surveys \(31\)](#)
[Research Initiatives](#)

clinical reports

To ensure that the information on this page is as accurate as possible, please set your ancestry on [your profile page](#).

Show results for

Print summary of elevated risks

Disease Risks (11)

	Type 2 Diabetes
	Atrial Fibrillation
	Venous Thromboembolism
	Psoriasis
	Rheumatoid Arthritis
	1 locked report

[See all 11 risk reports...](#)

Carrier Status (21)

Alpha-1 Antitrypsin Deficiency	Variant Absent
Bloom's Syndrome	Variant Absent
Canavan Disease	Variant Absent
Connexin 26-Related Sensorineural Hearing Loss	Variant Absent
Cystic Fibrosis	Variant Absent
	1 locked report

[See all 21 carrier status...](#)

Traits (10)

Alcohol Flush Reaction	Does Not Flush
Bitter Taste Perception	Unlikely to Taste
Earwax Type	Wet
Eye Color	Likely Blue
Lactose Intolerance	Likely Tolerant

[See all 10 traits](#)

Drug Response (7)

Response to Hepatitis C Treatment	Reduced
Warfarin (Coumadin®) Sensitivity	Increased
Abacavir Hypersensitivity	Typical
Clopidogrel (Plavix®) Efficacy	Typical
Drinking, Smoking, and Risk of Esophageal Cancer	Typical

[See all 7 drug responses](#)

Health

- Clinical Reports
- Research Reports
- Health Labs

Cystic Fibrosis

[← Prev](#)
[Next →](#)

Cutaneous Melanoma *Developmental Dyslexia*

Clinical Report on 31 reported markers.

[View all Carrier Status >](#)

- Your Data
- How It Works
- Timeline
- MD's Perspective
- Resources
- Technical Report

Ancestry

- Maternal Line
- Paternal Line
- Relative Finder
- Ancestry Painting
- Global Similarity
- Ancestry Labs

Technical Report

Show genotypes for: ▼

Sharing & Community

- Compare Genes
- Family Inheritance
- 23andMe Community

23andWe

- My Surveys (31)
- Research Initiatives

23andMe Name	Other Name(s)	DNA Change	Genotype	Result
i3000001	DeltaF508	CTT to <u> </u>	CTT,CTT	Does not have any of 31 CFTR mutations reported by 23andMe. Most likely no disease and not a carrier. May still be a carrier due to other mutations in the CFTR gene (not reported here)
i4000292	DeltaI507	ATC to <u> </u>	ATC,ATC	
i4000294	G85E	G to A	GG	
i4000295	R117H	G to A	GG	
rs35516286	I148T	T to C	TT	
i4000296	R334W	C to T	CC	
i4000297	R347P/H	G to C,A	GG	
i4000291	A455E	C to A	CC	
i4000299	V520F	G to T	GG	
i4000300	G542X	G to T	GG	
i4000301	S549N	G to A	GG	
i4000302	S549R	A to T	AA	
i4000305	G551D	G to A	GG	
i4000306	R553X	C to T	CC	
i4000307	R560T	G to C	GG	
i4000308	R1162X	C to T	CC	

clinical reports

Warfarin (Coumadin®) Sensitivity

Venous Th

Clinical Report on 3 reported markers.

[View all Drug R](#)

[Your Data](#)
[How It Works](#)
[Resources](#)
[Technical Report](#)

Technical Report

Show genotypes for:

SNP	Genotype	Combination	Result
rs1799853	TT	CYP2C9 *2/*2, VKORC1 -1639/3673 AA	Increased warfarin sensitivity. May require decreased warfarin dose.
rs1057910	AA		
rs9923231	TT		

Warfarin (Coumadin®) Sensitivity and Your Genes

People at risk for blood clots are often prescribed the blood thinner warfarin. But finding a patient's optimal dose of this life-saving drug, originally developed as a rat poison, is notoriously difficult. If too little warfarin is prescribed, the threat of blood clots will remain. But if too much drug is given, uncontrolled bleeding can result. Add to this the fact that "too little" and "too much" can vary significantly between people, and it's no wonder that complications from incorrect warfarin dosing are one of the most common reasons for emergency room

Raw genotype data: Navigenics

```
# This data file was generated by Navigenics Fri Sep 5 09:17 2008
# The file contains genotype calls from the Affymetrix Genome-Wide
# Human SNP Array 6.0.
# The genotyping was performed on behalf of Navigenics, Inc. by the
# CLIA-certified Affymetrix Clinical Services Laboratory (ACSL).
# The data was securely transmitted from ACSL in .chp format.
SNP_A-2131660 rs2887286 TT chr1 1145994 C/T
SNP_A-1967418 rs1496555 GG chr1 2224111 A/G
SNP_A-1969580 --- GG chr1 2319424 A/G
SNP_A-4263484 rs3890745 TT chr1 2543484 C/T
SNP_A-1978185 rs10492936 GG chr1 2926730 G/A
SNP_A-4264431 rs10489588 GG chr1 2941694 G/A
SNP_A-1980898 rs2376495 GC chr1 3084986 G/C
SNP_A-1983139 rs4648462 AA chr1 3155127 A/C
SNP_A-4265735 rs10492939 GG chr1 3292731 G/A
SNP_A-1995832 rs9424283 CG chr1 3695086 C/G
SNP_A-1995893 rs2154068 AG chr1 3710825 A/G
SNP_A-1997689 rs12060299 GG chr1 3753024 A/G
SNP_A-1997709 rs10909802 TT chr1 3753427 T/C
SNP_A-2004249 rs676853 AC chr1 4461025 A/C
```

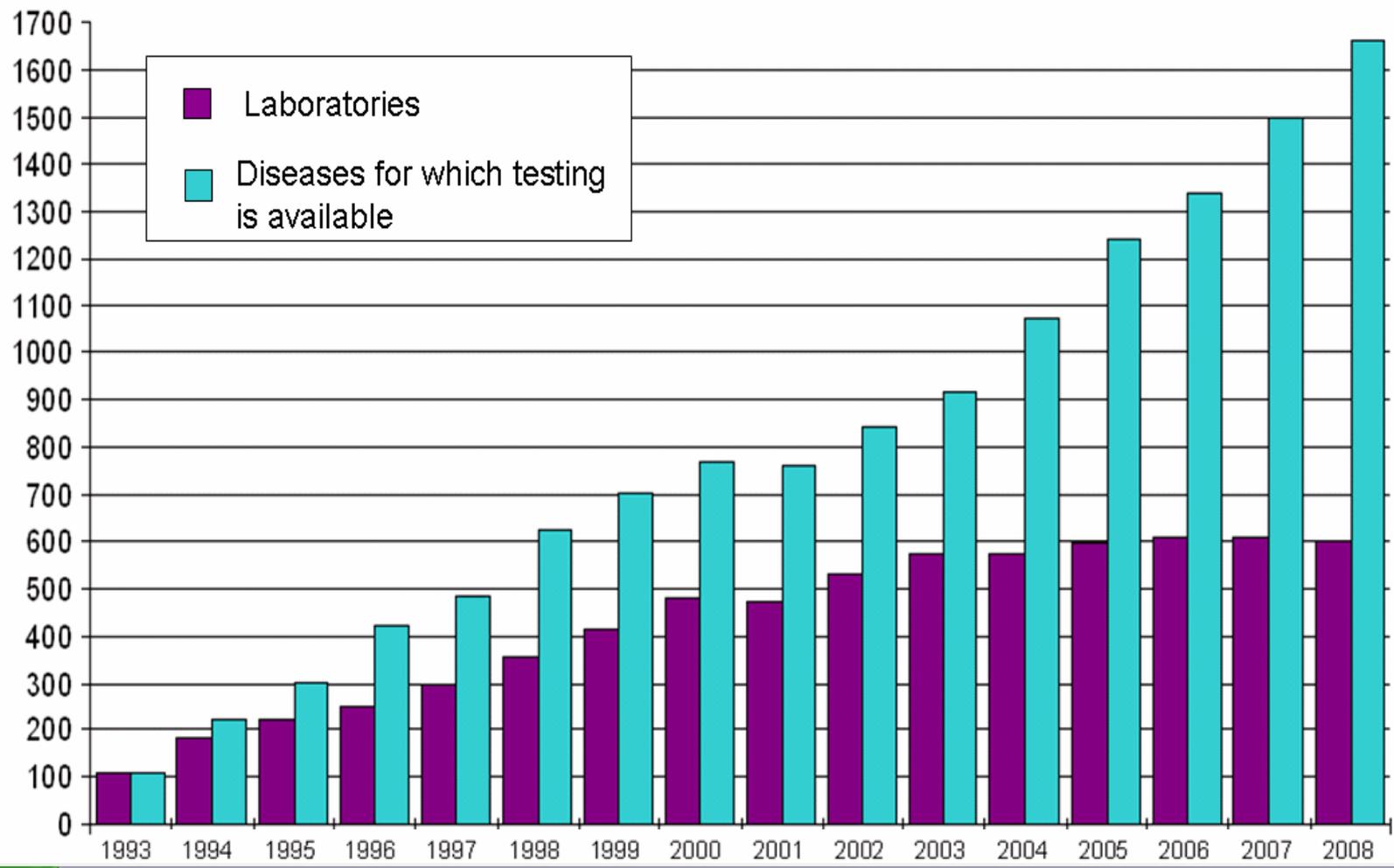
Genetics/Genomics in the EMR

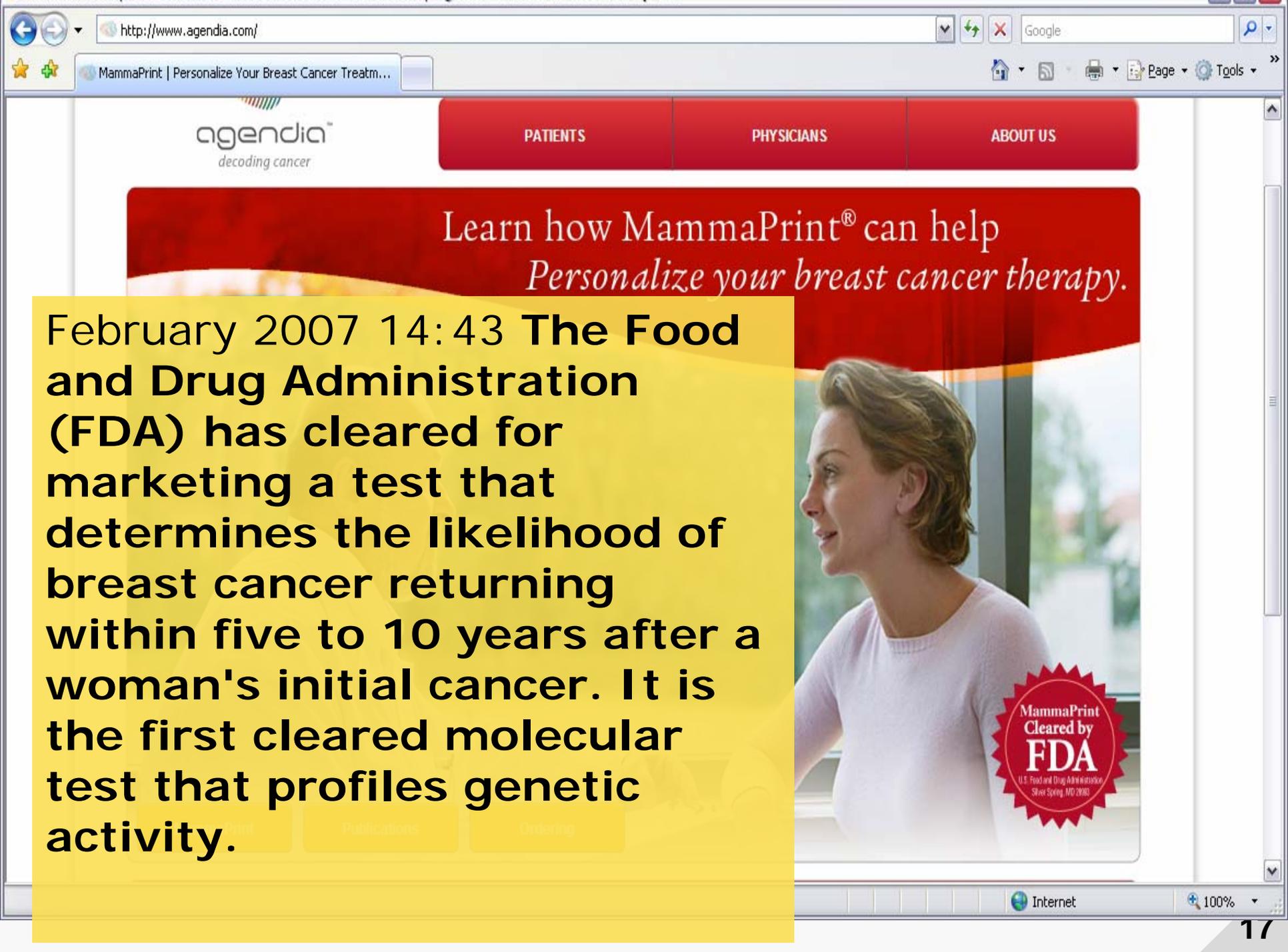


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GENE Tests: Growth of Laboratory Directory





agendia™
decoding cancer

PATIENTS

PHYSICIANS

ABOUT US

Learn how MammaPrint® can help
Personalize your breast cancer therapy.

February 2007 14:43 **The Food and Drug Administration (FDA) has cleared for marketing a test that determines the likelihood of breast cancer returning within five to 10 years after a woman's initial cancer. It is the first cleared molecular test that profiles genetic activity.**






AlloMap®
MOLECULAR EXPRESSION TESTING

A Breakthrough in Heart Transplant Patient Management

>> BILL M.'S STORY

Patients and Caregivers

To get additional AlloMap information for patients, [click here.](#)

Healthcare Providers

To get additional AlloMap information for clinicians, [click here.](#)

11 gene profile looking at expression changes related to the immune system

- Product Information**
- XDX Laboratory Services Guide for AlloMap® HTx Molecular Expression Testing
 - Material Safety Data Sheet (CPT Tubes)
 - Material Safety Data Sheet (Device)

Genetic Testing & EMR

- Tests done in 600 labs worldwide
- Test interpretation usually faxed
- Test results not stored in structured form
- Test results not available for decision support
- Test interpretation does not give details
- Clinicians struggle to explain tests.

Business Models

- Many gene tests are patented.
- Companies do not have a business model that promotes data sharing.
- Companies make money on not giving complete data.
- Contrast this with the DTC data sharing policies.

- Implications for component systems:
 - Laboratory
 - Pharmacy
 - Computerized order entry
 - Documentation and notes
 - Message and vocabulary standards
 - HL7 Clinical Genomics Standard



LDS Hospital

(801) 408-1100 Map
8th Avenue & C Street
Salt Lake City, UT 84103

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SCIENTISTS CLEAR MAJOR HURDLE IN GENETIC MEDICINE



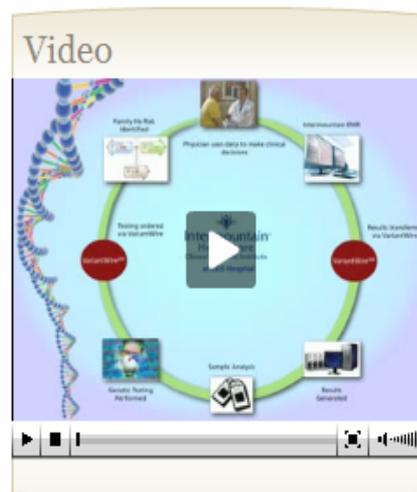
Intermountain Healthcare, LDS Hospital Genetic Scientists Team With Boston Health System to Clear Major Hurdle in Genetic Medicine

JESS GOMEZ
(801) 507-7455
Jess.Gomez@imail.org
9/30/2009

- A A A
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- BOOK MARK

Salt Lake City, UT (9/30/2009) - First-Ever Electronic Exchange of Genetic Data Paves Way for Medicine of the Future

Intermountain Healthcare and a genetics laboratory in Boston have made a breakthrough that may help lead to the medical record of the future and treatment plans that are tailor made for each



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Genome Data & Other Information Systems

- Genomic information is already pervasive in public health systems.
 - Newborn screening
 - Tissue and organ banks
 - DOD requires DNA samples
 - Identification of World Trade Center victims
 - Infective agent identification, origin & spread (e.g. SARS, H1N1)

Strategic Informatics Issues

- How to represent genetic data in electronic medical records [Helix]
- How to send structured genetic data between systems [HL7 CG]
- How to make this understandable to both providers and patients
- How do you keep all of this knowledge up to date?

Efficiency of CYP2C9 Genetic Test Representation for Automated Pharmacogenetic Decision Support

V. G. Deshmukh¹; M. A. Hoffman²; C. Arnoldi²; B. E. Bray¹; J. A. Mitchell¹

¹University of Utah, School of Medicine, Department of Biomedical Informatics, Salt Lake City, UT, USA;

²Cerner Corporation, Kansas City, MO, USA

Keywords

Pharmacogenetics, clinical decision support systems, SNP, allele

Summary

Objectives: We investigated the suitability of representing discrete genetic test results in the electronic health record (EHR) as individual single nucleotide polymorphisms (SNPs) and as alleles, using the CYP2C9 gene and its polymorphic states, as part of a pilot study. The purpose of our investigation was to determine the appropriate level of data abstraction when reporting genetic test results in the EHR that would allow meaningful interpretation and clinical decision support based on current knowledge, while retaining sufficient information in order to enable reinterpretation of the results in the context of future discoveries.

Methods: Based on the SNP & allele models, we designed two separate lab panels within the laboratory information system, one con-

taining SNPs and the other containing alleles, built separate rules in the clinical decision support system based on each model, and evaluated the performance of these rules in an EHR simulation environment using real-world scenarios.

Results: Although decision-support rules based on allele model required significantly less computational time than rules based on SNP model, no difference was observed on the total time taken to chart medication orders between rules based on these two models.

Conclusions: Both, SNP- and allele-based models, can be used effectively for representing genetic test results in the EHR without impacting clinical decision support systems. While storing and reporting genetic test results as alleles allow for the construction of simpler decision-support rules, and make it easier to present these results to clinicians, SNP-based model can retain a greater amount of information that could be useful for future reinterpretation.

Correspondence to:

Vikrant G. Deshmukh, M.Sc., M.S.
University of Utah, School of Medicine
Department of Biomedical Informatics
26 South 2000 East Room 5775
Salt Lake City, UT 84112
USA
E-mail: Vikrant.Deshmukh@hsc.utah.edu

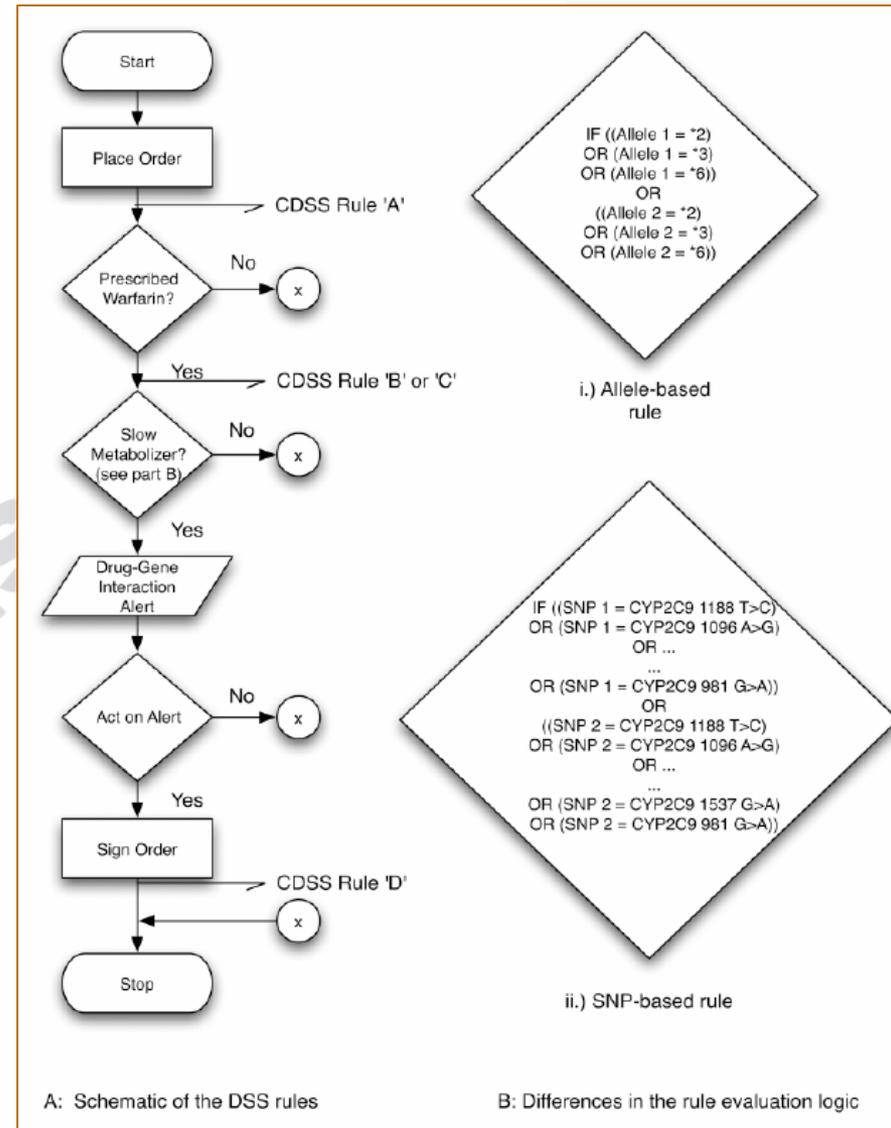
Methods Inf Med 2009; 48: ■-■

doi: 10.3414/ME0570

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published:



area of clinical molecular diagnostics [12, 13].

An allele is one of many alternate forms of a gene that occupies a given locus on a chromosome, and can consist of one or more

What is Coming?

- Next generation sequencing
- More public information (personal genome project)
- Environmental variables to correlate with genotype
- Human microbiome:
<http://nihroadmap.nih.gov/hmp/>
- Epigenetics
- Nanoparticles and nanomedicine
- More consumer activism
- Personal Health Records (PHRs)
- Personalized Medicine
- *And – all of this in the EMR??*

HIT Standards are Hot News

- HITSP – Health Information Technology Standards Panel – established 2005
- Public & private partnership to enable President Bush's/Obama's vision of establishing a nationwide system of electronic health record sharing by 2014.
- Chaired by Dr. John Halamka, Harvard
- Interim Final Rule issued 12-31-09 (2-12-10 effective)
 - <http://geekdoctor.blogspot.com/2009/12/interim-final-rule-on-standards.html>
 - http://mycourses.med.harvard.edu/ec_res/nt/11A2D479-1C5F-4E84-93E8-EBA58A0F1559/ifr.pdf

Effective Data Sharing Requires Standards for Data, Representation and Transmission



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Genetics Standards

- HL7 Clinical Genomic Standard
- CDA (RIM) drafted for genetic test result
- Gene expression data – MIAME
 - Exchange format: MAGE-TAB
- Proteomics data – MIAPE
 - Exchange format: mzML
- Vocabularies: SNOMED, Gene Ontology, Sequence Ontology, Protein Ontology, Clinical Bioinformatics Ontology
- But – these are emerging and immature

Questions?

Existing and Emerging
Information Technologies that
Affect Genomic Data Sharing



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