

# Genetics and the Electronic Medical Records: Where are we now? and Where are we going?

Kathi C Huddleston, PhD, RN  
Director, Clinical Projects  
November 8, 2018





# Genomic and Family data ..... A New Era in Medicine ...



**nature**

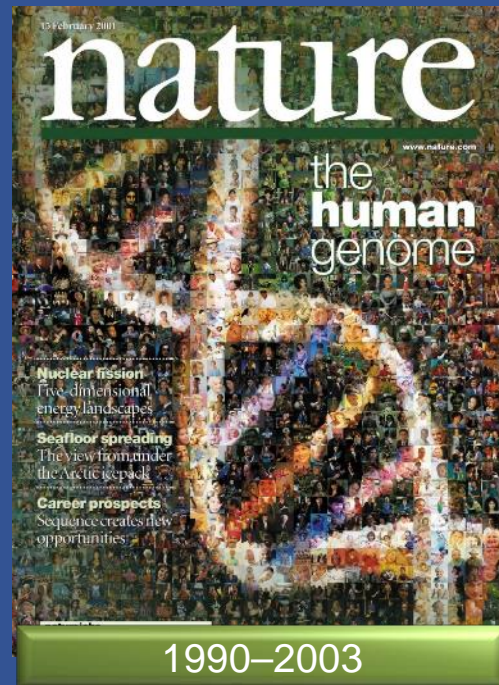
**insight commentary** [VOL. 429 | 27 MAY 2004]

## The case for a US prospective cohort study of genes and environment

Francis S. Collins

National Human Genome Research Institute, National Institutes of Health, Building 31, Room 4B09, MSC 2152, 31 Center Drive, Bethesda, Maryland 20892-2152, USA (e-mail: fc23a@nih.gov)

Information from the Human Genome Project will be vital for defining the genetic and environmental factors that contribute to health and disease. Well-designed case-control studies of people with and without a particular disease are essential for this, but rigorous and unbiased conclusions about the causes of diseases and their population-wide impact will require a representative population to be monitored over time (a prospective cohort study). The time is right for the United States to consider such a project.



13 February 2001

# nature

www.nature.com

## the human genome

**Nuclear fission**  
Five-dimensional energy landscapes

**Seafloor spreading**  
The view from under the Arctic ice pack

**Career prospects**  
Sequence creates new opportunities

1990-2003



**INOVA**<sup>®</sup>

Join the future of health.

# Longitudinal data and cohort studies



APRIL 1957 AMERICAN JOURNAL OF PUBLIC HEALTH

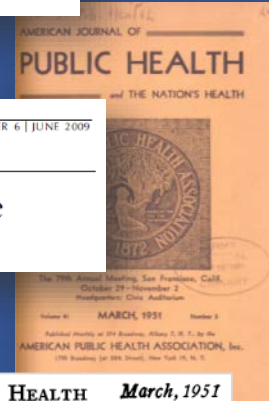
## II. Coronary Heart Disease in the Framingham Study

THOMAS R. DAWBER, M.D.; FELIX E. MOORE, F.A.P.H.A.; and  
GEORGE V. MANN, M.D.

nature  
genetics

VOLUME 41 | NUMBER 6 | JUNE 2009

Genome-wide association study of blood pressure  
and hypertension



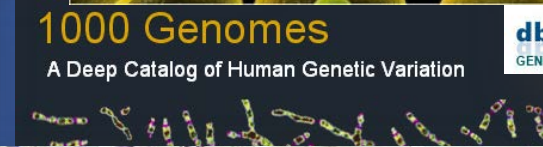
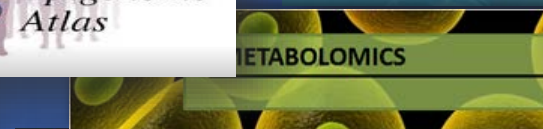
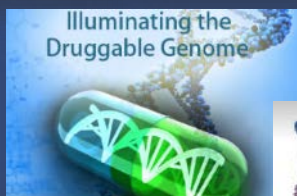
AMERICAN JOURNAL OF PUBLIC HEALTH *March, 1951*

## Epidemiological Approaches to Heart Disease: The Framingham Study\*

THOMAS R. DAWBER, M.D., GILCIN F. MEADORS, M.D.,  
M.P.H., AND FELIX E. MOORE, JR.

*National Heart Institute, National Institutes of Health, Public Health Service,  
Federal Security Agency, Washington, D. C.*

# Bigger data sources and more integration for personalized health



**Rethinking Clinical Trials™**  
A Living Textbook of Pragmatic Clinical Trials

**GTR: GENETIC TESTING REGISTRY**





Genomics



Data Science



Patient Partnerships



Technologies



EHRs

There are really only three important things to remember in life: To care, to share, and to be fair. This is not a new idea at all, and yet, observing how most people live their lives, you might think it was.

Frederick Lenz



WHERE?

WHO?

WHAT?

WHY.

WHEN?

HOW?



# What to Share?



Health Care Provider

Genetic Data

Existing DTC Data

Medical Data

Family History

Demographics

# With Whom to Share?



Health Care Provider

Genetic Data PGx Results

Medical Data

Existing DTC Data

Family History/ Family  
Genetic Results

Demographics



Clinical Care- The Hospital

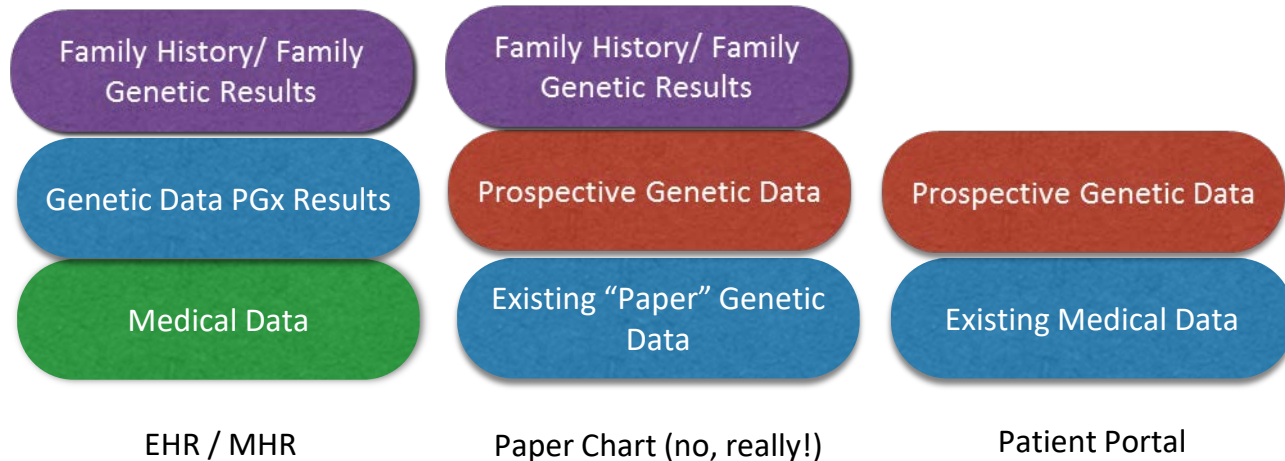


EPIC System



Scientific Community- Researchers

# How to Share? Now this is where the fun begins .....



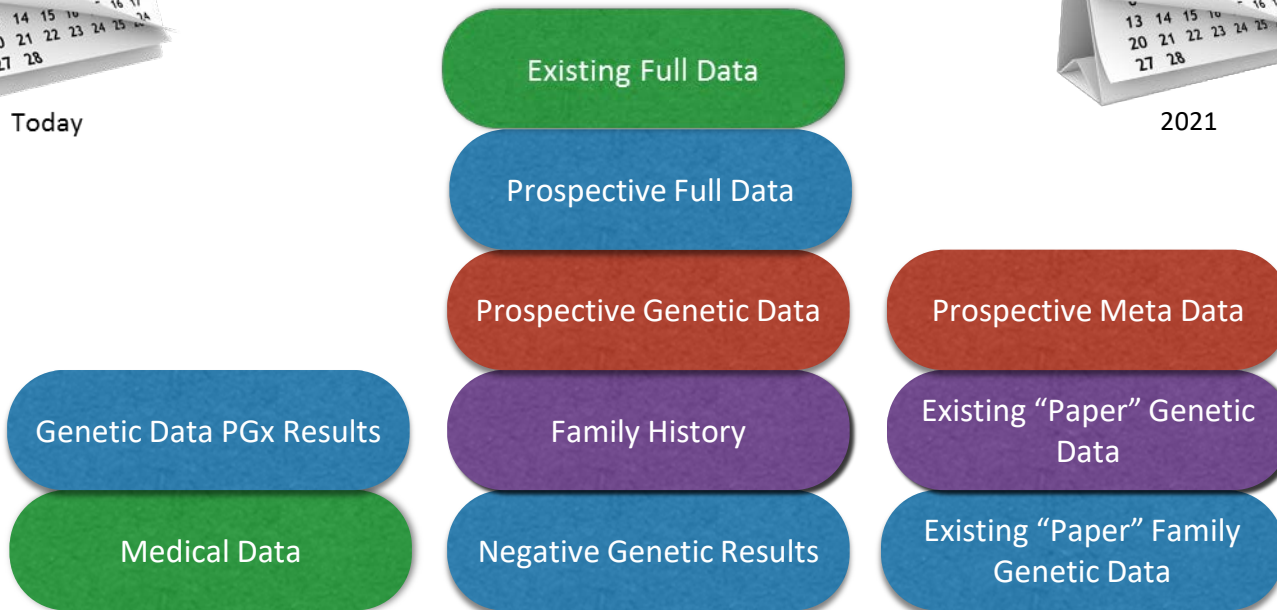
# When to Share?



Today



2021



EHR / MHR

Patient Portal

Paper Chart (no, really!)

# Whilst Carefully Considering & Balancing



Research Participant(s)



Scientific Community- Researchers



Health Care Professional



Clinical Care- The Hospital

New Discoveries,  
New Concerns,  
Ethical Dilemmas.

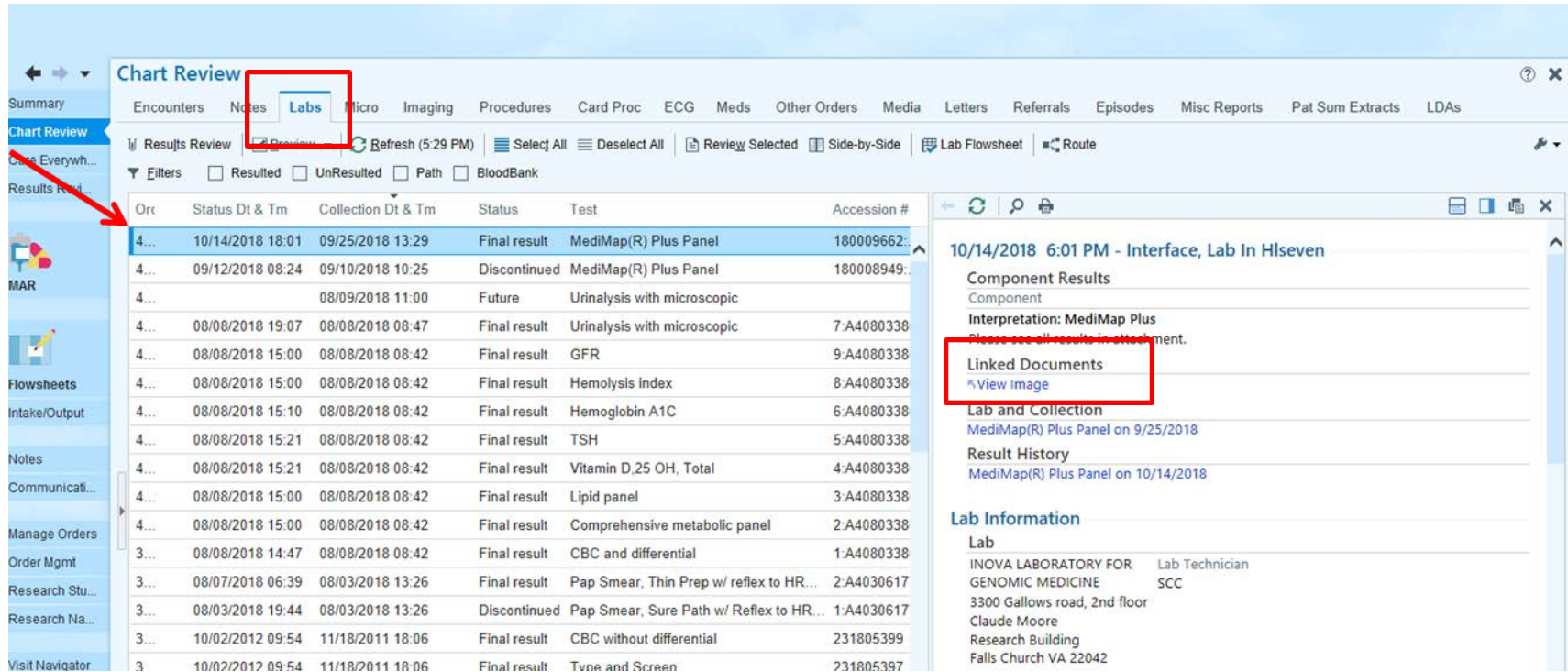


**INOVA**<sup>®</sup>

Join the future of health.



# How to find results in EPIC

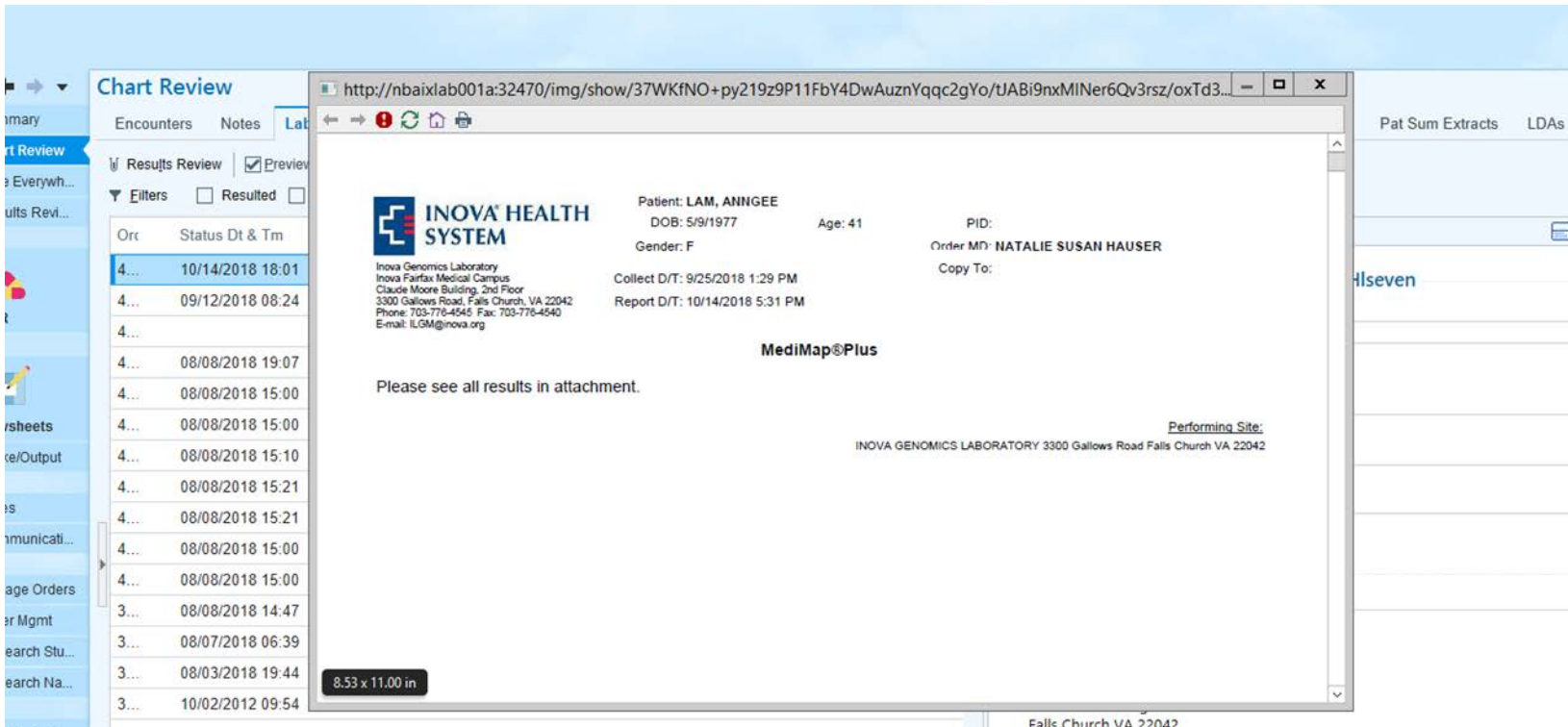


The screenshot displays the EPIC Chart Review interface. The top navigation bar includes tabs for Summary, Encounters, Notes, Labs, Micro, Imaging, Procedures, Card Proc, ECG, Meds, Other Orders, Media, Letters, Referrals, Episodes, Misc Reports, Pat Sum Extracts, and LDAs. The 'Labs' tab is selected and highlighted with a red box. Below the navigation bar, there are filters for Results Review (Resulted, UnResulted, Path, BloodBank) and a table of lab results. A red arrow points to the first row of the table, which is highlighted in blue. The table columns are: Or#, Status Dt & Tm, Collection Dt & Tm, Status, Test, and Accession #.

Or#	Status Dt & Tm	Collection Dt & Tm	Status	Test	Accession #
4...	10/14/2018 18:01	09/25/2018 13:29	Final result	MediMap(R) Plus Panel	180009662...
4...	09/12/2018 08:24	09/10/2018 10:25	Discontinued	MediMap(R) Plus Panel	180008949...
4...		08/09/2018 11:00	Future	Urinalysis with microscopic	
4...	08/08/2018 19:07	08/08/2018 08:47	Final result	Urinalysis with microscopic	7:A4080338
4...	08/08/2018 15:00	08/08/2018 08:42	Final result	GFR	9:A4080338
4...	08/08/2018 15:00	08/08/2018 08:42	Final result	Hemolysis index	8:A4080338
4...	08/08/2018 15:10	08/08/2018 08:42	Final result	Hemoglobin A1C	6:A4080338
4...	08/08/2018 15:21	08/08/2018 08:42	Final result	TSH	5:A4080338
4...	08/08/2018 15:21	08/08/2018 08:42	Final result	Vitamin D,25 OH, Total	4:A4080338
4...	08/08/2018 15:00	08/08/2018 08:42	Final result	Lipid panel	3:A4080338
4...	08/08/2018 15:00	08/08/2018 08:42	Final result	Comprehensive metabolic panel	2:A4080338
3...	08/08/2018 14:47	08/08/2018 08:42	Final result	CBC and differential	1:A4080338
3...	08/07/2018 06:39	08/03/2018 13:26	Final result	Pap Smear, Thin Prep w/ reflex to HR...	2:A4030617
3...	08/03/2018 19:44	08/03/2018 13:26	Discontinued	Pap Smear, Sure Path w/ Reflex to HR...	1:A4030617
3...	10/02/2012 09:54	11/18/2011 18:06	Final result	CBC without differential	231805399
3	10/02/2012 09:54	11/18/2011 18:06	Final result	Tvne and Screen	231805397

The right-hand pane shows a detailed view of the selected result: '10/14/2018 6:01 PM - Interface, Lab In Hlseven'. It includes sections for Component Results, Interpretation (MediMap Plus), Linked Documents (with a 'View Image' link highlighted in a red box), Lab and Collection (MediMap(R) Plus Panel on 9/25/2018), Result History (MediMap(R) Plus Panel on 10/14/2018), and Lab Information (INOVA LABORATORY FOR GENOMIC MEDICINE, Lab Technician SCC, 3300 Gallows road, 2nd floor, Claude Moore Research Building, Falls Church VA 22042).

# How to find results in EPIC



The screenshot displays the EPIC Chart Review interface. On the left, a sidebar contains navigation options such as 'Chart Review', 'Encounters', 'Notes', and 'Lab'. The main area shows a list of results with columns for 'Or', 'Status', 'Dt', and 'Tm'. The first result is highlighted in blue.

Or	Status	Dt	Tm
4...		10/14/2018	18:01
4...		09/12/2018	08:24
4...			
4...		08/08/2018	19:07
4...		08/08/2018	15:00
4...		08/08/2018	15:00
4...		08/08/2018	15:10
4...		08/08/2018	15:21
4...		08/08/2018	15:21
4...		08/08/2018	15:00
4...		08/08/2018	15:00
3...		08/08/2018	14:47
3...		08/07/2018	06:39
3...		08/03/2018	19:44
3...		10/02/2012	09:54

The preview window shows the following information:

**INOVA HEALTH SYSTEM**  
Inova Genomics Laboratory  
Inova Fairfax Medical Campus  
Claude Moore Building, 2nd Floor  
3300 Gallows Road, Falls Church, VA 22042  
Phone: 703-776-4545, Fax: 703-776-4540  
E-mail: ILGM@inova.org

Patient: LAM, ANNGEE  
DOB: 5/9/1977 Age: 41  
Gender: F  
Collect D/T: 9/25/2018 1:29 PM  
Report D/T: 10/14/2018 5:31 PM

PID: [blank]  
Order MD: NATALIE SUSAN HAUSER  
Copy To: [blank]

**MediMap®Plus**

Please see all results in attachment.

Performing Site:  
INOVA GENOMICS LABORATORY 3300 Gallows Road Falls Church VA 22042



# Universal Epic BPA Pop-Up



**INOVA** MEDIMAP™ Psychiatric Drug Panel

Category	Drug Class	Standard Precautions	Use With Caution	Consider Alternatives
Antidepressants	Antidepressives	Duloxetine (Cymbalta)	Duloxetine (Cymbalta) Escitalopram (Lexapro) Fluoxetine (Prozac, Sarafem) Paroxetine (Paxil) Sertraline (Zoloft) Venlafaxine (Effexor)	Citalopram (Celexa)
		Atomoxetine (Strattera)	Atomoxetine (Strattera)	
Antipsychotics	Antipsychotics	Haloperidol (Haldol) Risperidone (Risperdal) Ziprasidone (Geodon)	Haloperidol (Haldol) Risperidone (Risperdal) Ziprasidone (Geodon)	
Anti-ADHD Agents	Anti-ADHD Agents	Amphetamine (Adderall) Clonidine (Kapvay)	Amphetamine (Adderall) Clonidine (Kapvay)	
Anticonvulsants	Anticonvulsants	Carbamazepine (Carbatrol) Lamotrigine (Lamictal) Valproic Acid (Depakote)	Carbamazepine (Carbatrol) Lamotrigine (Lamictal) Valproic Acid (Depakote)	
Antidementia Agents	Antidementia Agents	Donepezil (Aricept) Galantamine (Razadyne)	Donepezil (Aricept) Galantamine (Razadyne)	

Private: No Patient Location: None Unit: None Bed: None Weight: 3.37 kg Birth Weight: 3645 g Code/Adv Dir: No Current Order Allergies: No Known Allergies ADA Special Needs: None Pref Language: **Unavailable** Need Interp: **No**

Place orders (Enc Date: 4/9/2016) - Wt: (Not entered for this visit) Ht: (Not entered for this visit)

SnapShot 
  Chart Review 
  Review Flowshe... 
  Results Review 
  Synopsis 
  Growth Chart 
  Medications 
  Immunizations 
  Order Entry 
  Education 
  Communications 
  ADA Special Ne... 
  Patient Station 
  Orders Only Enc...

Pref List 
  Interactions 
  Pharmacy 
  Providers 
  Routing 
  CC Results 
  References 
  Open Orders 
  Pend Orders 
  Sign/Nav 
  Fir

New order:  Search  Both  Medication  Procedure

New order defaults Not using defaults

Medications (1 Order)

**codeine 15 MG tablet**

Take 1 tablet (15 mg total) Print, R-0

**This patient has undergone Comprehensive Pharmacogenomic Panel - MediMap. This panel includes the drugs you are prescribing/dispensing and may contain relevant dosing guidance. Please review result prior to proceeding: .**

[Link to chart review](#)

Accept Cancel

# Result Interpretation & Reporting

Category	Drug Class	Standard Precautions	Use With Caution	Consider Alternatives
Psychotropic	Antiaddictives	Bupropion (Wellbutrin, Zyban, Aplenzin, Contrave) Disulfiram (Antabuse)	Naltrexone (Vivitrol)	
	Anti-ADHD Agents	Amphetamine (Adderall) Dextroamphetamine (Dexedrine) Lisdexamfetamine (Vyvanse)	Clonidine (Kapvay) Dexmethylphenidate (Focalin) Methylphenidate (Ritalin)	Atomoxetine (Strattera)
	Anticonvulsants	Fosphenytoin (Cerebyx) Lacosamide (Vimpat) Phenobarbital (Luminal) Phenytoin (Dilantin) Primidone (Mysoline) Zonisamide (Zonegran)		
	Antidementia Agents	Galantamine (Razadyne)	Donepezil (Aricept)	
		Desvenlafaxine (Pristiq) Duloxetine (Cymbalta) Escitalopram (Lexapro) Fluoxetine (Prozac, Sarafem)	Amoxapine (Amoxapine) Citalopram (Celexa)	Amitriptyline (Elavil) Clomipramine (Anafranil) Desipramine (Norpramin) Doxepin (Silenor) Imipramine (Tofranil)

Drug	Findings	What to Do - Dosing Regimens Suitable for Adult Patients
<b>Amitriptyline (Elavil)</b>	<ul style="list-style-type: none"> <li>Increased Sensitivity to Amitriptyline</li> <li>Genotype: CYP2D6 *4/*4</li> <li>Evidence Level: Actionable</li> </ul>	Select an alternative drug, or consider prescribing amitriptyline at a reduced dose (50% reduction) with monitoring of plasma concentrations of amitriptyline and nortriptyline.
<b>Clomipramine (Anafranil)</b>	<ul style="list-style-type: none"> <li>Increased Sensitivity to Clomipramine</li> <li>Genotype: CYP2D6 *4/*4</li> <li>Evidence Level: Actionable</li> </ul>	Consider an alternative drug, or prescribe clomipramine at 50% of the recommended standard starting dose. Monitor plasma concentrations of clomipramine and desmethylclomipramine, and titrate accordingly until a favorable response is achieved.
<b>Desipramine (Norpramin)</b>	<ul style="list-style-type: none"> <li>Increased Sensitivity to Desipramine</li> <li>Genotype: CYP2D6 *4/*4</li> <li>Evidence Level: Actionable</li> </ul>	Consider an alternative drug, or prescribe desipramine at 50% of recommended standard starting dose. Monitor plasma concentrations of desipramine and metabolites and titrate accordingly until a favorable response is achieved.

Drug	Findings	What to Do - Dosing Regimens Suitable for Adult Patients
<b>Amoxapine (Amoxapine)</b>	<ul style="list-style-type: none"> <li>Possible Sensitivity to Amoxapine</li> <li>Genotype: CYP2D6 *4/*4</li> <li>Evidence Level: Informative</li> </ul>	Like other tricyclic and tetracyclic antidepressants, amoxapine is metabolized by CYP2D6. However, the overall contribution of this enzyme in the metabolism of this drug is not well documented. Decreased CYP2D6 activity may result in higher amoxapine concentrations potentially leading to higher adverse events. There are no established dosing adjustments for patients with decreased CYP2D6 function therefore, therapy must be initiated cautiously and adjusted according to the patient's response.

## ***SUMMARY OF RESULTS***

---



### **RED CATEGORY**

*Based upon the patient's results, the medication has potentially reduced efficacy or increased toxicity. Medication change or dose adjustment with increased monitoring is highly recommended with this drug.*

---



### **YELLOW CATEGORY**

*Based upon the patient's results, the medication has potentially reduced efficacy or increased toxicity. Dose adjustment with increased monitoring may be needed with this drug.*

---



### **GREEN CATEGORY**

*Based upon the patient's results, the medication can be prescribed according to standard regimens.*

---

## PHARMACOGENOMIC TEST RESULTS

Gene	Genotype	Phenotype	Clinical Consequences
CYP2C19	*17/*17	Ultra-Rapid Metabolizer	Consistent with a significant increase in CYP2C19 activity. Potential risk for side effects or loss of efficacy with drug substrates.
CYP2C9	*1/*2	Intermediate Metabolizer	Consistent with a moderate deficiency in CYP2C9 activity. Potential risk for side effects or loss of efficacy with drug substrates.
CYP2D6	*1/*1	Normal Metabolizer	Consistent with a typical CYP2D6 activity. This test did not identify risks for side effects or loss of efficacy with drug substrates.
CYP3A5	*1/*3	Intermediate Metabolizer	Consistent with an intermediate CYP3A5 activity. Caution is advised when prescribing narrow therapeutic index drugs. Alternative drugs or dose adjustment may be required if CYP3A inhibitors or inducers are co-prescribed.
SLCO1B1	521T>C T/C	Decreased Function	Consistent with a decreased SLCO1B1 transporter function. The patient's risk for statin-induced myopathy is intermediate.
TPMT	*1/*1	Normal Metabolizer	Consistent with a typical TPMT activity and a typical risk of side effects with conventional doses of thiopurines.
VKORC1	-1639G>A A/A	High Warfarin Sensitivity	VKORC1 is the site of action of warfarin. The patient may require a substantial decrease in warfarin dose.

**Alleles Tested:** CYP2C19 \*2, \*3, \*4, \*4B, \*5, \*6, \*7, \*8, \*9, \*10, \*17; CYP2C9 \*2, \*3, \*4, \*5, \*6, \*7, \*8, \*9, \*10, \*11, \*13, \*15, \*16, \*27; CYP2D6 \*2, \*3, \*4, \*4M, \*6, \*7, \*8, \*9, \*10, \*11, \*12, \*14A, \*14B, \*15, \*17, \*20, \*29, \*35, \*41, \*5 (gene deletion), XN (gene duplication); CYP3A5 \*1D, \*2, \*3, \*3B, \*3C, \*3K, \*6, \*7, \*8, \*9; SLCO1B1 388A>G, 521T>C; TPMT \*2, \*3A, \*3B, \*3C, \*4; VKORC1 -1639G>A, 1542G>C, 2255C>T, 3730G>A, 5808T>G, 1173C>T

**Methodology:** Next generation sequencing based assay that detects the listed variants (please see "Variants Tested" for list of variants) with known clinical significance at analytical sensitivity and specificity >95%.

**Limitations:** This test will only detect a subset of all known variants that result in altered activity for the genes tested. Only a subset of gene variants that have strong evidence for clinical relevance and utility are reported here. 21 medications are evaluated in the MediMap test; fewer medications may appear on the report if the drug



