Diverse Clinical Implementations and Educational Programs In Pharmacogenomics: Experiences of the University of Florida (UF) Health Personalized Medicine Program

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Disclosure

• I declare no conflicts of interest, real or apparent, and no financial interests in any company, product, or service mentioned in this program, including grants, employment, gifts, stock holdings, and honoraria.
UF Health Personalized Medicine Program

• Working to add to the knowledge base about the role of genetic variation on drug response

• Establishing models and implementing use of genetic information to guide clinical decisions about drug use

• Developing educational programs and strategies to improve genomics education
UF Health Personalized Medicine Program - Moving pharmacogenetics to the clinic

NIH-NHGRI supporting efforts in Genomic Medicine Implementation

- IGNITE – Implementing GeNomics In pracTicE Network
  - Focused on unravelling the challenges associated with translating genomic medicine to clinical practice
  - 6 funded groups
    - University of Florida
    - Duke University
    - Mt Sinai
    - Vanderbilt
    - University of Maryland
    - University of Indiana
**UF IGNITE Project Aims**

- **Aim 1**: Extend UF program: new clinical & gene/drug pairs
- **Aim 2**: Current UF PMP Pgx testing
- **Aim 3**: Education of students, clinicians, patients
- **Expand testing to other sites**
Clinical Implementation of Pharmacogenomics
<table>
<thead>
<tr>
<th>Genes</th>
<th>Drug/ Drug class</th>
<th>Year of Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPMT</td>
<td>Thiopurines</td>
<td>2011, 2013, 2015</td>
</tr>
<tr>
<td>CYP2C19</td>
<td>Clopidogrel</td>
<td>2011, 2013</td>
</tr>
<tr>
<td>CYP2C9, VKORC1</td>
<td>Warfarin</td>
<td>2011</td>
</tr>
<tr>
<td>CYP2D6</td>
<td>Codeine</td>
<td>2011, 2015</td>
</tr>
<tr>
<td>HLA-B</td>
<td>Abacavir</td>
<td>2012, 2014</td>
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<tr>
<td>HLA-B</td>
<td>Allopurinol</td>
<td>2012, 2015</td>
</tr>
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<td>SLC01B1</td>
<td>Simvastatin</td>
<td>2012, 2014</td>
</tr>
<tr>
<td>CYP2C19, CYP2D6</td>
<td>TCAs</td>
<td>2013, 2015</td>
</tr>
<tr>
<td>HLA-B</td>
<td>Carbamazepine</td>
<td>2013</td>
</tr>
<tr>
<td>DPYD</td>
<td>Fluoropyrimidines</td>
<td>2014</td>
</tr>
<tr>
<td>IFNL3</td>
<td>Peginterferon alfa</td>
<td>2014</td>
</tr>
<tr>
<td>CFTR</td>
<td>Ivacaftor</td>
<td>2014</td>
</tr>
<tr>
<td>G6PD</td>
<td>Rasburicase</td>
<td>2014</td>
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<tr>
<td>CYP2C9, HLA-B</td>
<td>Phenytoin</td>
<td>2014</td>
</tr>
<tr>
<td>CYP2C19</td>
<td>SSRIs</td>
<td>2015</td>
</tr>
<tr>
<td>CYP3A5</td>
<td>Tacrolimus</td>
<td>2015</td>
</tr>
</tbody>
</table>
CYP2C19 and Clopidogrel: 2013 Updated CPIC Guideline

ACS/PCI Patients

CYP2C19 Genotyping

UM (*1/*17 or *17/*17)

EM (*1/*1)

IM (e.g. *1/*2)

PM (e.g. *2/*2)

Clopidogrel at a standard dose

Alternative antiplatelet (Prasugrel or Ticagrelor)

EHR Clinical Decision Support

This patient's CYP2C19 genotype is associated with very impaired metabolic activation of the produg clopidogrel (Plavix) and elevated risk for stent thrombosis or other cardiovascular events following PCI.

**REASONS**
Reduced clopidogrel activation in this genotype results in significantly reduced platelet inhibition, increased residual platelet aggregation, and decreased clopidogrel efficacy.

**RECOMMENDATIONS - MODIFY TREATMENT BY CHOOSING ONE OF THE FOLLOWING:**

(A) Prescribe prasugrel (EFFIENT) 10 mg daily
   *Contraindications:* History of stroke or transient ischemic attack, active bleeding
   *Caution:* Increased bleeding risk; Age > 75 years, Body weight < 60 kg

OR

(B) Prescribe ticagrelor (BRILINTA) 90 mg twice daily
   *Contraindications:* History of intracranial hemorrhage, active bleeding, severe hepatic impairment
   *Caution:* Aspirin doses > 100 mg/day reduce ticagrelor effectiveness and should be avoided.

More information on clopidogrel and CYP2C19

Last CYP2C19 = **2*8** on 4/12/2012

Administrative and other disclosures:

- Open order: Place order for prasugrel (EFFIENT) 10 mg daily. Note: remove order for clopidogrel on next screen.
  (Last done by Ellen Kershner at 2:50 PM on 4/18/2012)
- Open order: Place order for ticagrelor (BRILINTA) 90 mg twice daily. Note: remove the clopidogrel order on next screen.
  (Last done by Inpatient Physician, MD at 12:12 PM on 5/18/2012)
- Open order: Proceed with clopidogrel (Plavix) 75 mg daily. Note: please remove the bottom or second clopidogrel order as it will duplicate.
  (Last done by inpatient Physician, MD at 12:17 PM on 4/26/2012)
Message sent: This alert has been sent via In Basket
First year, CYP2C19 ordered on patients with left heart cath for suspicion of coronary disease.

- 1097 orders for CYP2C19 test
  - 28% of patients testing had a variant allele
- Among 291 PCI patients, 84% were genotyped, with genotype orders increasing over time
  - First 2 months (June and July 2012) – 63% genotyped
  - Last 2 months (May and June 2013) – 98% genotyped
Clopidogrel PGx: Progress since year 1

• Changed from grant-supported to clinically-billed genotyping and less-intensive support
  – Cardiologists transitioned to order only post-PCI
  – Approx 70% of PCI patients have test ordered
  – Hospital agreed to cover genotyping cost under DRG (inpatient PCI patients)
  – Insurance companies paying approx. 85% of the time. Only Medicaid has not reimbursed test
  – Over 1500 clinical tests completed to date
MACE at 30 Days According to CYP2C19 Genotype
(Data from UF Health PMP presented at ASCPT, March 2015)

n=318 post-PCI patients
(78% with ACS)

n=99 with a LOF allele*

- n=41 APT not switched
  - Clopidogrel 75 mg/d
- n=58 APT switched
  - Prasugrel (n=50)
  - Ticagrelor (n=5)
  - Clopidogrel 225 mg/d (n=3)

n=219 no LOF allele

CV death, MI, CVA, stent thrombosis at 30 days

- n=5 12.2%
- n=0 0%
- n=6 2.7%

p=0.010  p=0.349

*LOF, loss of function allele (e.g. CYP2C19 *1/*2 or *2/*2 genotype)
Outcome Data from IGNITE PGx Working Group

• Prospective multi-center investigation of clinical CYP2C19 genotype-guided antiplatelet therapy post-PCI
• Primary outcome - Major Adverse Cardiac Events (MACE)
  – Death, myocardial infarction, or stroke within 12 months following index PCI
    – Compared between patients with a loss-of-function (LOF) allele on alternative vs. clopidogrel therapy
    – Also compared between patients with a LOF allele on alternative therapy vs. patients without a LOF allele
Outcome Data from IGNITE PGx Working Group

Total Cohort
n=1815

LOF
n=572 (31.5%)

- Clopidogrel
  n=226 (39.5%)
- Alternative
  n=346 (60.5%)*†

non-LOF
n=1243 (68.5%)

- Clopidogrel
  n=1050 (84.5%)
- Alternative
  n=193 (15.5%)†

*p<0.0001 for Alternative therapy between LOF and non-LOF groups
Kaplan-Meier Survival Curve

Adjusted Hazard Ratio
LOF-CLOP vs LOF ALT: $2.21 \ (1.13-4.33) \ p=0.021$
LOF-ALT vs non-LOF: $0.81 \ (0.48-1.35) \ p=0.41$

Log-rank $p=0.016$
Log-rank $p=0.15$
Clinical Implementation at UF Health Jacksonville

• Collaboration with Dr. Dominic Angiolillo and team
• CYP2C19 genotyping on all patients presenting for cardiac cath with suspicion of CAD
• Using Spartan Rx genotyping system (genotype data available before leaving cath lab)
• Have genotyped over 700 patients since April
Major Implementation Accomplishments

- CYP2C19 for clopidogrel in post-PCI patients (UF Health)
- TPMT for 6-MP in ALL patients
- TPMT for thiopurines in Peds and Adult GI
- IL28B/INFL3 genotype-guided peginterferon
- CYP2D6 for pain in Oncology (Moffitt Cancer Center)
- CYP2D6/CYP2C19 for guiding antidepressants
- (SSRIs) child psychiatry clinic
- CYP2D6 for pain medications in Family Medicine (One Florida)
Clinical Implementations at UF Health Shands Hospital

CYP2C19-Clopidogrel
Launch 6/25/12

IFNL3-Peg-interferon alpha
Launch 7/1/14

CYP2D6/CYP2C19-SSRIs
Launch 10/12/16

TPMT-Thiopurines
Launch 2/3/14

CYP2D6-Opioids
Launch 5/11/15

CYP2C19-PPIs
Launch 1/24/17

CYP2D6 and oplate therapy

• Conducting a clinic-level implementation study of CYP2D6 to guide pain therapy, assessing outcomes with electronic, iterative pain rating scale
  – Target enrollment n=500; enrollment complete in April
  – Lead - Lari Cavallari

Jeff Cruse: “Taking that test has changed my life. It’s going to change a lot of people’s lives.”
Other Implementations

- CYP2D6/CYP2C19 genotype to guide SSRI therapy in pediatric psychiatry patients
  - CTSI pilot project
- CYP2C19 guided PPI therapy
  - IGNITE admin supplement project in collaboration with Nemours Children’s Health System
- TPMT genotype to guide thiopurines
- Several collaborative projects with Cancer Center team
TPMT and Thiopurines

- In February 2014, launched TPMT testing to dose thiopurines in the inpatient setting of Pediatric Hematology/Oncology.
- Follow by an inpatient/outpatient launch in July in Adult and Pediatric GI for IBD patients.
- Coordinated through the standard medication use processes within UF Health.
- Associated with:
  - Clinical decision support in Epic.
  - Availability of consultation for interpreting and applying TPMT test results.
## TPMT and Thiopurines

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>AZA or 6-MP</th>
<th>TG</th>
</tr>
</thead>
</table>
| Homozygous wild-type       | • Start with normal dose  
                              | • Allow 2 weeks to reach steady state   |                                             |
| Normal, high activity      |                                                                           |                                             |
| Heterozygote               | • Reduce dose by 30-70%                                                  | • Reduce dose by 30-50%                    |
| Intermediate activity      | • Adjust based on tolerance  
                              | • 2-4 weeks to reach steady state for each adjustment  |                                             |
| Homozygous variant         | • Consider alternatives for non-malignant conditions  
                              | • Reduce daily dose 10X and frequency to thrice weekly (from 5X weekly)  
                              | • 4-6 weeks to reach steady state for each adjustment | Low activity |                                             |

Standard AZA starting dose: 2-3 mg/kg/day  
Standard 6-MP starting dose: 1.5 mg/kg/day
Thiopurine Prescribed

TPMT genotype known

High activity genotype

No alert

Intermediate activity genotype

6-MP
For malignancy, refer to protocol.
For non-malignant conditions, reduce dose by 30-70%.

AZA
Reduce dose by 30-70% (non-malignant conditions).

TG
For malignancy, refer to protocol.
For non-malignant conditions, reduce dose by 30-50%

Low activity genotype

6-MP
For malignancy, refer to protocol.
For non-malignant conditions, consider alternative non-thiopurine therapy

AZA
Consider alternative agents. If using AZA reduce dose 10 fold and reduce frequency to thrice weekly (non-malignant conditions).

TG
For malignancy, refer to protocol.
For non-malignant conditions, consider alternative non-thiopurine therapy

TPMT genotype unknown

Alert provider to order TPMT

- N = 845 patients
  - 803 TPMT enzyme orders for 739 patients
  - 154 TPMT genotype orders for 147 patients
  - 41 patients received both tests
  - 58 patients received multiple enzyme orders, 17 did not result

- Test turnaround time was shorter for genotype than enzyme:
  - 5 (IQR 3-7) vs. 6 days (IQR 5-8; p<0.0001)
# TPMT Test Orders

<table>
<thead>
<tr>
<th>Ordering Service</th>
<th>Genotype</th>
<th>Enzyme</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (n=845)</td>
<td>147</td>
<td>739</td>
</tr>
<tr>
<td>Hem/onc (n=41)(^1)</td>
<td>40 (97.6%)</td>
<td>2 (4.9%)</td>
</tr>
<tr>
<td>Non-hem/onc (n=804)(^2)</td>
<td>107 (13.3%)</td>
<td>737 (91.7%)</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

\(^1\) Hem/onc patient received both tests  
\(^2\) 40 Non-hem/onc patients received both tests

## Top ordering services for each test\(^1\)

**Genotype:**
1. GI: 65 (44.2%)  
2. Hem/onc: 41 (27.9%)  
3. Rheumatology: 11 (7.5%)

**Enzyme:**
1. GI: 473 (61.4%)  
2. Rheumatology: 66 (8.6%)  
3. Dermatology: 65 (8.4%)

\(^1\) Of the tests with a result

- Groups outside of hematology/oncology displayed reduced adoption of \textit{TPMT} genotyping
- Discordant results were more likely to occur in non-hem/onc patients with multiple enzyme testing than those with genotyping plus enzyme testing
- Logistic regression did not identify factors associated with enzyme-genotype discordance
- Providers outside of hematology/oncology may need education on new evidence on the benefits of genotyping
<table>
<thead>
<tr>
<th>Test</th>
<th>Drug</th>
<th>Number of tests</th>
<th>Ordering Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYP2C19</td>
<td>Clopidogrel</td>
<td>1694</td>
<td>Cardiology, UF Health Shands</td>
</tr>
<tr>
<td></td>
<td></td>
<td>634</td>
<td>Cardiology, UF Health Jacksonville</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>Neurology, Neurosurgery</td>
</tr>
<tr>
<td>TPMT</td>
<td>Thiopurines</td>
<td>43</td>
<td>Hematology/Oncology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>67</td>
<td>Gastroenterology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>42</td>
<td>Other*</td>
</tr>
<tr>
<td>IFNL3</td>
<td>PEG-interferon-α based regimens</td>
<td>96</td>
<td>Gastroenterology</td>
</tr>
<tr>
<td>CYP2D6</td>
<td>Opioids</td>
<td>202</td>
<td>Family Medicine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33</td>
<td>Internal Medicine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>34</td>
<td>Chronic Pain Clinic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>Adult Oncology</td>
</tr>
<tr>
<td>CYP2D6</td>
<td>SSRIs</td>
<td>12</td>
<td>Psychiatry</td>
</tr>
<tr>
<td>CYP2C19</td>
<td>SSRIs</td>
<td>13</td>
<td>Psychiatry</td>
</tr>
<tr>
<td>CYP2C19</td>
<td>PPIs</td>
<td>40</td>
<td>Gastroenterology</td>
</tr>
</tbody>
</table>

*Dermatology, Rheumatology, Neurology, Internal Medicine, Family Medicine, Surgery

Education in Genomic Medicine and Pharmacogenomics
Practitioner Knowledge and Comfort Level

- **Schwartz et al:**
  - 72% of hospital pharmacists (n = 660) favor implementing PGx
  - Only 25% confident in abilities to interpret pharmacogenomic test results

- **Roederer et al:**
  - 83% of pharmacists rated their knowledge of pharmacogenomics as ‘poor’ or ‘fair’

- **McCullough et al:**
  - 85% of pharmacists agreed that pharmacists should be required to be knowledgeable about pharmacogenomics
  - 63% felt they could not accurately apply pharmacogenomics test results to drug therapy, selection, and monitoring
Practitioner Knowledge and Comfort Level

- Agree that genetic variants influence drug response: 90
- Feel adequately informed about PGx testing: 10
- Ordered a PGx test in the previous 6 months: 20

Why is genomics different?

• Lack of appropriate training in school and continuing education
  – Lag time between rate of evidence and technology development and their integration into education and practice

• Lack of clinical experience with pharmacogenomics activities and tools
  – Underrepresented in clinical training
  – How to find, interpret, and apply evidence
  – How to understand and compare different pharmacogenomics tests

How do we get over the hurdle?
Participatory Genotyping

Using participatory genomic testing with learners can create a “push” teachable moment.

Figure 1. Teachable moments are distinguished by a cueing event (also called a triggering or sentinel event) that increases perception of risk, elicits an emotional response, and/or represents a life experience that changes an individual’s self-concept or one of their social roles [10]. In the case of the Stanford GENE 210 curriculum, the cueing event was the experience of personal genotyping. The students who were surveyed overwhelmingly felt that having their personal data motivated them to acquire new knowledge (the course material) and skills.

Participatory genomic testing in the classroom

• N = 31 medical and graduate students
  – 23 students underwent personal genome testing
  – 8 students used a de-identified dataset

• Students’ reflections
  – 83% of tested students stated they were pleased with their decision versus 12.5% of non-tested students

• Students’ knowledge
  – 70% of tested students self-reported a better understanding on the basis of testing
  – Tested students demonstrated a mean 31% increase in pre- to post-test scores on knowledge questions (significantly higher than those not tested)

Salari K et al. PLOS One. 2013;8:e68853.
Personal Genotyping In the Classroom

- Pharmacogenomics course
  - N = 37
    - All students underwent personal genotyping
- Genomic Medicine Course
  - N = 21 students
- Both courses
  - N = 16 students completed both courses in sequence and completed pre- and post-course surveys in both courses
Pharmacogenomics Knowledge

# Attitudes/Beliefs: Health Care Professionals

<table>
<thead>
<tr>
<th></th>
<th>Pre-Course</th>
<th>Post-Course</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence in communicating clinical PGx recommendations</td>
<td>2.7</td>
<td>3.9</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Comfortable answering questions from other HCPs about PGx</td>
<td>2.8</td>
<td>3.8</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>I understand role of other HCPs in applying clinical PGx data</td>
<td>3.5</td>
<td>4.1</td>
<td>0.0001</td>
</tr>
<tr>
<td>I understand role of my profession in applying clinical PGx data</td>
<td>3.6</td>
<td>4.2</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

N = 37; Responses to questions based on Likert scale (1=strongly disagree and 5=strongly agree)

# Effect of Participatory Genotype Testing on Knowledge, Attitudes and Beliefs

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Genotyping</td>
<td>Single SNP analysis (rs1801280) within NAT2</td>
<td>Commercial laboratory testing (23andMe)</td>
<td>Panel-based testing in research laboratory for relevant clinical SNPs</td>
<td>Commercial laboratory testing (23andMe)</td>
<td>Single gene encoding drug metabolizing enzyme or pharmacodynamics-relevant protein in research lab</td>
<td>Single gene testing of TAS2R38 with phenotype testing</td>
</tr>
<tr>
<td>Effect on Attitudes and Beliefs</td>
<td>Increased understanding of PGx analysis Highlighted importance of this topic to future practice Greater increase in confidence Improved student’s self-perceived ability to empathize</td>
<td>Improved self-reported understanding Increased comfort level and confidence</td>
<td>Greater increase in confidence Improved students’ reflections and attitudes toward PGx</td>
<td>Increase in mean attitude pre- vs. post, but not significantly different in genotyped vs. non-genotyped students</td>
<td>Perceptions of and confidence in their abilities in pharmacogenomics patient care skills areas improved</td>
<td></td>
</tr>
</tbody>
</table>

Effects of Personal Genotyping on Student Knowledge and Self-Efficacy

Knowledge-based metrics were compared between the CTR and INT group.

Collected via pre- and post-course survey

Teaching strategies differed between the CTR and INT group

Metrics collected on pre- and post-survey and statistical methods

<table>
<thead>
<tr>
<th>Metrics of student preparedness</th>
<th>Comparison</th>
</tr>
</thead>
</table>
| Knowledge                       | • Pre-course knowledge test scores for INT vs. CTR (*Student’s t-test*)  
|                                 | • Post-course knowledge test scores for INT vs. CTR (*Student’s t-test*)  
|                                 |   • 15 case-based questions in “Knowledge of PGx” section  
|                                 | (1 per lecture/topic) |
| Correlation of confidence with knowledge (i.e. do students actually know what they think they know?) | • Pre-course: Correlation of student confidence with knowledge for each group (*Spearman correlation*)  
|                                 | • Post-course: Correlation of student confidence with knowledge for each group, controlling for pre-survey knowledge (*Spearman correlation*)  
|                                 | • Confidence level with each question in the “Knowledge of PGx” section |
# Teaching strategies by course

<table>
<thead>
<tr>
<th>Teaching strategies</th>
<th>Elective Clinical PGx Course</th>
<th>Required PGx Course</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Both patient case-based, interactive and traditional didactic strategies</td>
<td>Solely traditional didactic strategies</td>
</tr>
</tbody>
</table>

## Activities

- Pre-recorded lectures
- Required readings
- Regularly scheduled quizzes
- Exams
- Discussion board assignments
- Journal evaluation assignments
- Patient cases prior to in-class discussions

- Patient case discussion in class with faculty
- Optional personal genotyping during the class
- Option to use personal genotype results to solve patient cases

- Pre-recorded lectures
- Required readings
- Regularly scheduled quizzes
- Exams
## Baseline characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Intervention Group (n=21)</th>
<th>Control Group (n=31)</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female sex, n (%)</td>
<td>8 (38%)</td>
<td>22 (71%)</td>
<td>0.019</td>
</tr>
<tr>
<td>Race, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>11 (52%)</td>
<td>23 (74%)</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>1 (5%)</td>
<td>1 (3%)</td>
<td>0.262</td>
</tr>
<tr>
<td>Asian</td>
<td>6 (29%)</td>
<td>5 (16%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>3 (14%)</td>
<td>2 (6%)</td>
<td></td>
</tr>
<tr>
<td>Ethnicity, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>4 (19%)</td>
<td>7 (23%)</td>
<td>0.760</td>
</tr>
</tbody>
</table>
Knowledge Results

Pre-course:
No difference in test scores between INT and CTR (6.8 vs 6.3; $p=0.3407$)

Post-Course:
Higher post-course knowledge test score in INT vs CTR group (10 vs 7.5; $p=0.0001$)
Correlation of confidence with knowledge

CTR Group:
No correlation between students’ confidence and knowledge for pre-course \((r=0.22, p=0.23)\) or post-course (adjusted \(r=0.07, p=0.70\))

INT Group:
Students’ confidence and knowledge were not correlated pre-course \((r=0.34, p=0.13)\), but did correlate post-course (adjusted \(r=0.46, p=0.04\))
Genomic Medicine
Implementation Practice and
Research Resources
How to Get Started: Implementing Genomics in Practice

SPARK Toolbox

www.ignite-genomics.org
How to Get Started: Implementing Genomic Medicine

Just getting started? The tools below provide background information, benefits of adoption of genomic medicine in patient care, and summarize key challenges and stakeholders to consider for your implementation.

Ready to begin implementing? See specific resources below for common pharmacogenomic and genomic medicine implementations.

+ Clinical Implementation of Genomic Medicine and Pharmacogenomics

+ CYP2C19 - Clopidogrel
+ CYP2C19 - Clopidogrel

+ CYP2D6 - Opioids

+ CYP2D6 and CYP2C19 - SSRIs

+ TPMT - Thiopurines

+ Family History

+ APOL1
CYP2C19 - Clopidogrel

+ Evidence Overview: CYP2C19 – Clopidogrel
+ Clinical Implementation Publications: CYP2C19-Clopidogrel
+ Clinical Pharmacogenetics Implementation Consortium Guideline Resources: CYP2C19-Clopidogrel
+ PharmGKB Resources: CYP2C19
+ Genotyping Resources: CYP2C19
+ Implementation Workflow Examples: CYP2C19-Clopidogrel
+ Clinical Decision Support: CYP2C19-Clopidogrel
+ Data Collection and Implementation Metrics: CYP2C19-Clopidogrel
+ Resources for Patients and Providers: CYP2C19-Clopidogrel
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<tr>
<th>Resources for Patients and Providers: CYP2C19-Clopidogrel</th>
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<tr>
<td>• Information on Genetic Testing for Clopidogrel (Plavix)</td>
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<tr>
<td>Source: University of Florida Health Personalized Medicine Program</td>
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<td>• Video: CYP2C19 and Clopidogrel (Plavix) Response NEW</td>
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<td>Source: Coriell Personalized Medicine Collaborative</td>
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<td>• Patient Education Brochure for Clopidogrel NEW</td>
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<td>Source: Icahn School of Medicine at Mount Sinai</td>
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<td>• CYP2C19 Summary for Patients and Their Families NEW</td>
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<td>Source: St. Jude Children's Research Hospital</td>
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<tr>
<td>• CYP2C19-Clopidogrel Pharmacogenomic Lab Test Summary</td>
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<td>Source: Mayo Clinic Center for Individualized Medicine</td>
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<td>• Guide for Patient Consultation about Pharmacogenomics</td>
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<td>Source: Indiana University</td>
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<tr>
<td>• Medical Genetics Summary: Clopidogrel Therapy and CYP2C19 Genotype NEW</td>
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<td>Source: NIH National Center for Biotechnology Information</td>
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<td>• CYP2C19 Information Page NEW</td>
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<td>• PMP Clopidogrel Handout</td>
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<td>• Education Handouts NEW</td>
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<td>Source: Cincinnati Children's Hospital</td>
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Summary

- UF in a leadership position in implementing precision medicine, particularly genomic medicine
- Have documented approaches to advancing research findings into clinical practice
- Documented improved CV outcomes with CYP2C19 genotype-guided antiplatelet therapy
- Multiple different implementations/ pragmatic studies underway
UF Health Personalized Medicine Program Acknowledgements

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