Integrating ‘Big Data’ to Advance Population Health: The first 5 years of the JHU Center for Population Health IT (CPHIT)

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Want to watch this presentation “live”?  

- This session was recorded and is available online.  
- Go to the URL below and fast forward about 2 minutes to where the presentation starts.  

http://webcast.jhu.edu/Mediasite/Play/10dbbd96d1ac454ba1ccefbdbab11be31d

Speakers: Jonathan Weiner, DrPH & Hadi Kharrazi, MHI MD PhD

Health Sciences Informatics Grand Rounds  

Mar 31 2017
Integrating ‘Big Data’ to Advance Population Health: The first 5 years of the JHU Center for Population Health IT (CPHIT)

CME Learning Objectives

- Articulate conceptual and data integration frameworks developed by CPHIT and others to help define the field of population health informatics.

- Describe the trajectory and current portfolio of CPHIT research involving integration of 20+ million EMR records, tens of millions of insurance claims, consumer data, GIS data, public health data, and social/human services data.

- Provide examples of population health research in obesity in veterans, in frailty risk prediction, in the Maryland All Payer Waiver population and in predicting adverse opioid outcomes.

Speakers: Jonathan Weiner, DrPH & Hadi Kharrazi, MHI MD PhD

Health Sciences Informatics Grand Rounds

Mar 31 2017
Overview of Session

- **CPHIT background**
  - Mission
  - Collaboration

- **Population Health Informatics**
  - Emerging Field
  - Data Sources
  - Drivers (*incentives; mandates; standards*)
  - The National Population Health Informatics Workshop

- **Examples of CPHIT R&D Portfolio**
  - Moving the ACG System to EHRs (eACG)
  - VHA BMI Trajectory
  - HIE-based Readmission Prediction
  - Extracting Frailty Factors from EHRs
  - Falls Prediction Modeling
  - DHMH Population Health Metrics

- **Research Challenges and Future R&D / Open Discussion**
Center for Population Health IT (CPHIT)
The Johns Hopkins Center for Population Health Information Technology

(CPHIT, or “see-fit”)

- **Mission** of this innovative, multi-disciplinary R&D center is to improve the health and well-being of populations by advancing the state-of-the-art of Health IT across public and private health organization.

- CPHIT focuses on the application of electronic health records (EHRs), mobile health and other e-health and HIT tools targeted at communities and populations.

- Also R&D for the widely used **JHU ACG** Predictive Modeling software system (in use in 30+ nations for 160M+ patients) is housed in CPHIT.

[Links: JHU ACG Website, CPHIT Website]
CPHIT → Partnerships

- JH Health System
- JH Health Care
- JHU Academic Departments and other R&D centers
- CPHIT
- External PH/IDS Orgs.
- JH Healthcare Solutions, LLC
- Business Partners
- Industry Foundations
- Government
Population Health Informatics
Population Health Informatics: An Integration of Three Disciplines
A proposed national research and development agenda for population health informatics: summary recommendations from a National Expert Workshop

Hadi Kharrazi1,2, Elyse C Lasser1, William A Yasnow2,3, John Loonsk1, Aneel Advani1, Harold P Lehmann2, David C Chin1, Jonathan P Weiner1,2

ABSTRACT

Objective The Johns Hopkins Center for Population Health IT hosted a 1-day symposium sponsored by the National Library of Medicine to help develop a national research and development (R&D) agenda for the emerging field of population health informatics (PopHI).

Material and Methods The symposium provided a venue for national experts to brainstorm, identity, discuss, and prioritize the top challenges and opportunities in the PopHI field, as well as R&D areas to address these.

Results This manuscript summarizes the findings of the PopHI symposium. The symposium participants’ recommendations have been categorized into 13 overarching themes, including policy alignment, data governance, sustainability and incentives, and standards/interoperability.

Discussion The proposed consensus-based national agenda for PopHI consisted of 18 priority recommendations grouped into 4 broad goals: (1) Developing a standardized collaborative framework and infrastructure, (2) Advancing technical tools and methods, (3) Developing a scientific evidence and knowledge base, and (4) Developing an appropriate framework for policy, privacy, and sustainability. There was a substantial amount of agreement between all the participants on the challenges and opportunities for PopHI as well as on the actions that needed to be taken to address these.

Conclusion PopHI is a rapidly growing field that has emerged to address the population dimension of the Triple Aim. The proposed PopHI R&D agenda is comprehensive and timely, but should be considered only a starting-point, given that ongoing developments in health policy, population health management, and informatics are very dynamic, suggesting that the agenda will require constant monitoring and updating.

JAMIA Paper Reporting on the Findings from the National Workshop
Population Health Informatics \arrow{\rightarrow} National Workshop on Pop Health IT
(cont.)

Population Health Informatics vs Public Health Informatics vs Clinical Informatics
(Venn diagram of population denominator)
Population Health Informatics → National Workshop on Pop Health IT (cont.)

<table>
<thead>
<tr>
<th>Domain</th>
<th>Population Health Informatics</th>
<th>Public Health Informatics</th>
<th>Clinical Informatics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common Intervention Targets</strong></td>
<td>• Total population</td>
<td>• Total population</td>
<td>• Clinician</td>
</tr>
<tr>
<td></td>
<td>• Target populations</td>
<td></td>
<td>• Patient or consumer</td>
</tr>
<tr>
<td></td>
<td>• Provider organization</td>
<td></td>
<td>• Provider organization</td>
</tr>
<tr>
<td></td>
<td>• Healthcare systems</td>
<td></td>
<td>• Target population</td>
</tr>
<tr>
<td><strong>Main Operational Goal</strong></td>
<td>• Outreach and prevention</td>
<td>• Assessment</td>
<td>• Treatment</td>
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<td>• Care integration</td>
<td>• Prevention</td>
<td>• Rehabilitation</td>
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<td></td>
<td>• Disease management</td>
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<td><strong>Action Arm</strong></td>
<td>• Population health organization</td>
<td>• Public health agencies</td>
<td>• Clinical organizations</td>
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<td></td>
<td>• Care management organizations</td>
<td>• Non-for-profit and non-governmental organizations</td>
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<tr>
<td><strong>Key Stakeholders</strong></td>
<td>• Provider and payer systems</td>
<td>• Federal, state, and local governments</td>
<td>• Providers</td>
</tr>
<tr>
<td></td>
<td>• Government and community</td>
<td></td>
<td>• Consumers</td>
</tr>
<tr>
<td><strong>Key Information Challenges</strong></td>
<td>• Capturing non-medical info</td>
<td>• Expanding public health IT systems</td>
<td>• Decision support</td>
</tr>
<tr>
<td></td>
<td>• Information system interoperability across sectors</td>
<td>• Medical and public health interoperability</td>
<td>• EHR interoperability</td>
</tr>
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</table>

Population Health Informatics vs Public Health Informatics vs Clinical Informatics
CPHIT Research Portfolio
CPHIT Current R&D Portfolio

- **eACG**: Developing a wide range of state-of-the-art EHR-based population focused predictive modeling of the “e-ACG” tools
  - EHR ICD and e-prescribing Rx input (coordinated with claims)
  - Non-claims data: Lab Data; BMI and Vitals; and Social History

- **VHA**: Collaborating with the Veteran Health Administration
  - Developed population health analytic framework
  - Linking geo and social data for obesity trend analysis
  - Adding social/geo framework to PCMH (PACT) case finding program

- **Frailty**: Developing a new geriatric/frailty “e-risk” score utilizing structured and unstructured (free text) EHR data and Claims
CPHIT Portfolio (cont.)

- **Falls Prevention**: Developing analytics with Baltimore City Health Dept for regional collaboration to identify and predict elder’s fall injuries in the community using social, medical, and PH data

- **Predicting Opioid Overdose**: Using multiple novel sources of data to develop predictive models to identify persons at risk for opioid overdose
  - CRISP/HIE’s PDMP data; Department of Justice; & DHMH

- **Consumer Data**: Linking consumer/marketing data with medical data to identify health outcomes (e.g., consumer reports)

- **Community Level e-Measures**: Collaborating with Maryland State Health Department, HIE and Hospital Commission
  - Assist in the building of a statewide population health digital measurement infrastructure for “waiver” and beyond
  - Develop population health focused measures
CPHIT Portfolio → Select Data sources

- Sample list of data sources
  - IMS Claims / Truven-IBM Claims
  - OptumLabs (United Healthcare) Claims + EHR
  - Claims and EHR records of various national and regional integrated health delivery systems
    - VHA (35M pts), Atrius, HealthPartners (soon - JHHS)
  - Maryland’s HSCRC (case-mix / hospital discharges)
  - Maryland’s MHCC (all-payer claims database)
  - Maryland’s HIE (CRISP; health information exchange)
  - and other novel sources of data...
CPHIT Portfolio → VHA Population Health Framework and BMI Trajectory

- **Aim (1):** Contextualize obesity factors within VHA’s population health framework
- **Aim (2):** Design a scalable pop-health ‘technical’ platform and develop a pilot for obesity
- **Aim (3):** Derive and evaluate “VHA’s Obesity Trajectory Population-based Risk Prediction Model” to measure the GIS-clustered population-based factors that affect the management of obesity

### Population % in each obesity category

<table>
<thead>
<tr>
<th>Obesity Category</th>
<th>Population %</th>
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<tr>
<td>Underweight (BMI&lt;18.5)</td>
<td>1.07%</td>
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<tr>
<td>Normal (BMI&gt;=18.5)</td>
<td>19.12%</td>
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<tr>
<td>Overweight (BMI&gt;=25.0)</td>
<td>35.96%</td>
</tr>
<tr>
<td>Obese Class I (BMI&gt;=30.0)</td>
<td>26.21%</td>
</tr>
<tr>
<td>Obese Class II (BMI&gt;=35.0)</td>
<td>11.55%</td>
</tr>
<tr>
<td>Obese Class III (BMI&gt;=40)</td>
<td>6.09%</td>
</tr>
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</table>

### Average BMI per obesity category

<table>
<thead>
<tr>
<th>Obesity Category</th>
<th>Average BMI</th>
</tr>
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<tbody>
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<td>Underweight (BMI&lt;18.5)</td>
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<tr>
<td>Normal (BMI&gt;=18.5)</td>
<td></td>
</tr>
<tr>
<td>Overweight (BMI&gt;=25.0)</td>
<td></td>
</tr>
<tr>
<td>Obese Class I (BMI&gt;=30.0)</td>
<td>37.09</td>
</tr>
<tr>
<td>Obese Class II (BMI&gt;=35.0)</td>
<td>46.82</td>
</tr>
<tr>
<td>Obese Class III (BMI&gt;=40)</td>
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</tr>
</tbody>
</table>

Prevalence of obesity among VHA population — visits to 29,322 visits occurred in one day of 2013; generated using CDW data
Ongoing Projects → VHA Population Health Framework and BMI Trajectory (cont.)

Geographic distribution of obesity among VHA population

(Limited to 29,322 visits occurred in one day of 2013; generated using CDW data)
Ongoing Projects → VHA Population Health Framework and BMI Trajectory (cont.)

County BMI (using MLM adjustment) for Males 2000-2015
Ongoing Projects → VHA Population Health Framework and BMI Trajectory (cont.)

County BMI (using MLM adjustment) for Males 2015 (DC and Baltimore)
Ongoing Projects → VHA Population Health Framework and BMI Trajectory (cont.)

Interactive Web-based Real-time Geo-Temporal Exploration of Obesity Data (Showing averages of 2014 for MD)
CPHIT Portfolio → Predicting Falls among Elderly Residents of Baltimore City

- Baltimore Falls Reduction Initiative Engaging Neighborhoods & Data (B’FRIEND)

- B’FRIEND is a public-private partnership in Baltimore City based on innovative use of health data to decrease the rate of falls leading to an emergency room (ER) or hospital admission among elderly.

- Aim (1): Develop and validate a case identification methodology;

- Aim (2): Develop and validate a fall’s risk prediction model

- Aim (3): Evaluate the fall risk score and disseminate results

Prevalence of falls among elderly in Baltimore City zip codes (based on HIE cross-sectional data)
New analysis will be at the Census Block Level
## Preliminary Model of Clinical Predictors and coefficients of the B’FRIEND model

| Predictors                        | Estimate | Std. error | z value | Pr(>|z|) | Significance | OR   | 2.50% | 97.50% |
|-----------------------------------|----------|------------|---------|----------|--------------|------|-------|--------|
| History of fall                   | 1.795    | 0.074      | 24.113  | <2e-16   | ***          | 6.02 | 5.20  | 6.97   |
| Fracture                          | 0.604    | 0.104      | 5.821   | 5.85E-09 | ***          | 1.83 | 1.49  | 2.24   |
| Substance Abuse                   | 0.520    | 0.082      | 6.364   | 1.96E-10 | ***          | 1.68 | 1.43  | 1.97   |
| Parkinson                         | 0.337    | 0.178      | 1.895   | 0.058056 | .            | 1.40 | 0.98  | 1.97   |
| Kyphoscoliosis                    | 0.322    | 0.153      | 2.102   | 0.035519 | *            | 1.38 | 1.01  | 1.85   |
| Sex (female)                      | 0.173    | 0.046      | 3.736   | 0.000187 | ***          | 1.19 | 1.09  | 1.30   |
| Depression                        | 0.146    | 0.068      | 2.141   | 0.032238 | *            | 1.16 | 1.01  | 1.32   |
| Mental Illness                    | 0.128    | 0.065      | 1.980   | 0.047652 | *            | 1.14 | 1.00  | 1.29   |
| Age                               | 0.038    | 0.003      | 14.895  | <2e-16   | ***          | 1.04 | 1.03  | 1.04   |
| Charlson Index                    | -0.053   | 0.009      | -5.711  | 1.12E-08 | ***          | 0.95 | 0.93  | 0.97   |
| Vision                            | -0.211   | 0.057      | -3.689  | 0.000225 | ***          | 0.81 | 0.72  | 0.91   |
| Obesity                           | -0.251   | 0.076      | -3.311  | 0.000931 | ***          | 0.78 | 0.67  | 0.90   |
| Cardiovascular Disease            | -0.313   | 0.050      | -6.301  | 2.95E-10 | ***          | 0.73 | 0.66  | 0.81   |
| Lower Urinary Tract Symptoms      | -0.345   | 0.074      | -4.656  | 3.23E-06 | ***          | 0.71 | 0.61  | 0.82   |
| Hypertension                      | -0.357   | 0.050      | -7.080  | 1.44E-12 | ***          | 0.70 | 0.63  | 0.77   |
| Cancer                            | -0.441   | 0.081      | -5.418  | 6.02E-08 | ***          | 0.64 | 0.55  | 0.75   |
| Lower Back Pain                   | -0.495   | 0.067      | -7.368  | 1.73E-13 | ***          | 0.61 | 0.53  | 0.69   |
| Joint Trauma                      | -0.526   | 0.197      | -2.674  | 0.007487 | **           | 0.59 | 0.39  | 0.85   |
| Lower Extremity Joint Surgery     | -1.069   | 0.182      | -5.870  | 4.36E-09 | ***          | 0.34 | 0.24  | 0.48   |
| (Intercept)                       | -4.372   | 0.197      | -22.249 | <2e-16   | ***          | 0.01 | 0.01  | 0.02   |

Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
HIE-based Real-Time Hospital Readmission Prediction

Health Information Exchange (HIE)
HIE-based Readmission Prediction (cont.)

CRISP Encounter Notification System + Readmission Risk Prediction Model (RRPM) integration
HIE-based Readmission Prediction (cont.)

Advance RRPM integration in CRISP Encounter Notification System

Notice: Risk of readmission for patient is high.

Simulate outcome

Drag sliders to see the estimated effect on readmission risk score
CPHIT and DHSI involved in Education

- **National Pop Health IT Curriculum and Workforce Training:**
  Developing a national curriculum for Population Health IT and training more than 6000 healthcare professional incumbents

- **Health IT Education Opportunities @ healthit.gov**

ONC has awarded seven grantees $6.4 million to update instructional materials from the original Workforce Curriculum Development program funded under HITECH. In addition to updating these materials, the goal of this program is to train 6,000 incumbent health care professionals to use new health information technologies in a variety of settings including:

- Patient-centered medical homes
- Team-based care environments
- Accountable care organizations
- Long-term care facilities
- Hospitals
- Clinics

The updates will focus on the 5 new key topic areas of

- Care Coordination & Interoperable Health IT Systems
- Health Care Data Analytics
- Patient-Centered Care
- Population Health
- Value-Based Care

Some of the grantees are recruiting incumbent health care professionals to participate in their training offerings.

Funded by ONC, all of these training courses will be available free of charge.

On this table are fliers with more information about the available programs
The Johns Hopkins ACG risk measurement / predictive modeling system

Billions of dollars per year are now routinely exchanged using the JHU ACG system across the US and in 27+ nations. Healthcare of as many as 180+ million patients is actively managed and monitored using ACGs on all continents. Over 1000+ peer reviewed articles have been published regarding ACGs. CPHIT is the academic/R&D home of ACGs.

JHU ACG Website - hopkinsacg.org
“e-ACGs” -- EHRs and other HIT systems offer profound opportunities to expand ACG metrics

**Clinical Domain**
- Symptoms/Physical Status
- Diagnostics
- Therapeutics
- Medical History
- Genomics

**Consumer Domain**
- Socio-Economic
- Behavioral/Lifestyle
- Family
- Preferences
- Knowledge/Attitudes
- Community Factors
- Access to Care/Services
Comparing level diagnoses found in Claims vs. EHR

Each column represents the % of patients whose Disease (ACG/EDC) shows up in claims only “c”, EHR only “e” or both “ce”

Records in EHRs only

More records in Claims + EHRs than other sources of Dx

More records in Claims than other sources of Dx

Source: JHU CPHIT Analysis of Health Partners (MN) EHR Data n=110K
Adding risk information from EHR clinician notes using “natural language processing” (NLP) text mining

Comparisons of structured EHRs, claims, and NLP from notes for two functional/social factors among elderly cohort

**Walking Difficulty**

<table>
<thead>
<tr>
<th>Free Text</th>
<th>Claims</th>
<th>EHR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1875</td>
<td>152</td>
<td>371</td>
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<tr>
<td>167</td>
<td>309</td>
<td>694</td>
</tr>
<tr>
<td>269</td>
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</table>

**Social Support**

<table>
<thead>
<tr>
<th>Free Text</th>
<th>Claims</th>
<th>EHR</th>
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<tbody>
<tr>
<td>2023</td>
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</tr>
<tr>
<td>4</td>
<td>3</td>
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<tr>
<td>3</td>
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</tr>
</tbody>
</table>

CPHIT analysis using Epic Records of 20K Medicare HMO members at “AtriusHealth” (affiliate of Harvard Pilgrim). Note the accuracy of the NLP case identification for these factors was over 95% based on clinician chart review of sample cases.
Maryland’s new all-payer hospital fixed budget “waiver” is providing extraordinary pop health analytic opportunities

<table>
<thead>
<tr>
<th>Category</th>
<th>Maryland Performance</th>
<th>Cumulative Target</th>
<th>Period</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>All-Payer Hospital Spending Growth Per Capita</td>
<td>4.14%</td>
<td>11.13%</td>
<td>Jan '14 - Dec '16 vs. 2016 ceiling</td>
<td>HSCRC monthly financial data</td>
</tr>
<tr>
<td>Medicare Hospital Spending Growth Per Beneficiary</td>
<td>$533 million in savings</td>
<td>$132 cumulative savings at year 3</td>
<td>Jan '14 - Nov '16 vs. 2016 target</td>
<td>CMS data*</td>
</tr>
<tr>
<td>Medicare All Provider Spending Growth Per Beneficiary</td>
<td>-1.18% spending difference (MD growth rate was -0.16%)</td>
<td>0% no more than above national growth rate (national growth rate was 1.02%)</td>
<td>Jan '16 - Nov '16 vs. CY 2016 target</td>
<td>CMS data*</td>
</tr>
<tr>
<td>Medicare Readmission Rate</td>
<td>-5.96% decrease</td>
<td>-5.15% decrease or more</td>
<td>Jan '14 - Oct '16 vs. 2013 Base Year</td>
<td>CMS data, V. 6*</td>
</tr>
<tr>
<td>Maryland Hospital Acquired Conditions Rate</td>
<td>-46.45% decrease</td>
<td>-13.31% decrease or more</td>
<td>Jan '16 - Sep '16 vs. Jan '13 - Sep '13</td>
<td>HSCRC data</td>
</tr>
</tbody>
</table>

Maryland Hospital Association Statewide Dashboard on 3/17
A Conceptual Model for Understanding Community Level Population Health in Maryland

**DHMH/Waiver Interventions**
- DHMH / HSCRC
- Hospital System
- Health Departments

**Other Interventions**
- Other Medical
- Other Public Health
- Other Non-Medical

**Cross Sector Coordination**

**Health System Factors**
- Access
- Capacity
- Effectiveness

**Type of Services/Programs**
- Medical Care
- Public Health
- Other Service Programs

**Key Social Determinants**
- Healthy Behavior (Psychological influences)
- Social Environment
- Physical Environment

**Population and Key Subgroups**
- Healthy
- Special Need
- Super Utilizer
- Pregnant
- Child
- Adults
- Elders

**Population/Community Health/Wellness**
- Mortality
- Morbidity (Intermediate/Long Term)
- Life Function
- Social/Emotional Wellbeing
- Environmental/Physical Safety

**Key population Health Measures**
# Reflects medical care oriented measures that may not reflect pop health unless at geo level

Source: JHU CPHIT
Mapping Digitally Derived Metrics Into a Population Health Framework

<table>
<thead>
<tr>
<th>Overview of Population Health Measurements</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Target Population</strong></td>
<td><strong>Life Courses</strong></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy</td>
<td>Across Target Populations &amp; Life Courses</td>
</tr>
<tr>
<td>Pregnant</td>
<td>Child/ Adolescent</td>
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<tr>
<td>Special Needs</td>
<td>Across Target Populations &amp; Life Courses</td>
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<td>Pregnant</td>
<td>Child/ Adolescent</td>
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<tr>
<td>Super Utilizers</td>
<td>Across Target Populations &amp; Life Courses</td>
</tr>
<tr>
<td>Pregnant</td>
<td>Child/ Adolescent</td>
</tr>
</tbody>
</table>

(See measure mapping codes linked to specific measures on next slide)
Proposed Community/Population Level Measures to serve as Maryland “All Payer” “P4P” Targets

1. Diabetes-related emergency department visits for community/population (A1/A2)
2. Asthma-related emergency department visits for community (A1/A2)
4. Screening for high blood pressure and follow-up for community/population (A3/C2/PQ)
5. Food – nutrition; fruit and vegetable consumption for population (B1)
6. Counseling on Physical Activity in the Population (B1)
7. Current adult smoking within population (B1)
8. Median household income within population (B2)
9. Levels of housing affordability and availability (B2/B3)
10. Age-adjusted mortality rate from heart disease for population (C1)
11. Addiction-related emergency department visits (A1/C2)
12. Falls; Fall-related injury rate (A4/B3/C1/C2/C3)
13. Social connections and isolation (B2)
14. Functional Outcome Assessment (B1/C2)
15. Self-Reported Health Status (C2)

Codes refer to section of framework on previous slide
# Initial Assessment of Alternative Data Sources For Each Pop Health Measure

## Summary of Potential Data Sources Contributing to Recommended Population Health Measures and The Expected level of Available Geographic Details

<table>
<thead>
<tr>
<th>Measure by number:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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[State Innovation Model: Population Health Planning in Maryland](#)
A vision for an integrated Md. population health information platform

Maryland’s Population Health Informatics Backbone

Patient Experience Metrics
Population Health Metrics
Healthcare Cost

MD All-Payer Population Health Analytics Core

State-wide Population Health Data-warehouse

Claims (HSCRC, CMS)
National Data (HCAHPS, CDC, QBR, PQI)
Local Metrics (MD’s SHIP)

New Data Sources?

EHRs

1...n

HIE (CRISP)

Informatics Unit at HSCRC/DHMH

A
B
C

DHMH to Provider

Provider to DHMH

DHMH to Pro.
CPHIT / Maryland Department of Health / CRISP project funded by US DoJ to link diverse data sets to develop patient “risk scores” to predict Adverse Opioid Outcomes
Opioid Abuse Predictive Risk Project: Potential Data Sources, Risk Factors and Outcomes

**Data Sources**
- HSCRC Inpatient/Outpatient Hospital Encounter Case Mix Data
- PDMP Prescription Data
- Incarceration Data
- Payor Claims Data
- Electronic Health Records
- Substance Abuse Treatment/Behavioral Health Data
- Emergency Services Medical Data
- State Social Services Data
- Office of the Chief Medical Examiner Data

**Factors/Indicators**
- **Clinical Factors**
  - Demographics
  - Previous ED and Inpatient Encounters
  - Length of hospitalization
  - Diagnoses
- **Prescription History Factors**
  - Quantity and types of drugs
  - Dosing/Rapid Escalation
  - Concurrent prescriptions
  - “Doctor/pharmacy shopping” behavior
  - Method of payment
- **Criminal History Factors**
  - History of arrests related to opioids
  - History of substance use
  - Length of stay
  - Health services received by offender
- **Social Services Factors**
  - Child and protective services
  - Public Housing
  - Food stamps
- **Illicit Drug Use Factors**
  - History of illicit drug use
  - Injection use
  - Withdrawal in past 6 months
  - Homelessness

**Outcomes**
- Substance Use Disorder Diagnosis
- Naloxone Administration
- Non-Fatal Overdose
- Substance Abuse Treatment Enrollment
- Arrest or Incarceration
- Fatal Overdose

Encounters with systems result in the collection of identifiable data. Factors can be used in predictive models as separate domains or can be combined.
The next 5 years: HIT-based analytic innovations and opportunities for population health

- Unprecedented opportunity to link diverse electronic data sources
- Predict health outcomes beyond cost and utilization
- A wide array of new electronic data sources both medical and social
- Target broader timeframes and populations
- Models more accurate (and complex)
- “Pop decision support” can be integrated into the electronic health care workflow