Translational Research for Surveillance

Integrated Surveillance Seminar Series
from the
National Center for Public Health Informatics
January 28, 2008

Joe Lombardo

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Outline

1. A definition of public health informatics translational research

2. Identify translational research opportunities in PHI needed to improve public health practice in surveillance

3. Introduce selected surveillance enhancement projects
   a. Advanced querying to rapidly create more productive and timely analysis groupings (moving from syndromic to case specific surveillance)
   b. Customizable alerting analytics
   c. Public health collaborations (overcoming data sharing obstacles)

4. Discussion
National Cancer Institute Technical Working Group Definition

"Translational research transforms scientific discoveries arising from laboratory, clinical, or population studies"
National Cancer Institute Technical Working Group Definition

"Translational research transforms scientific discoveries arising from laboratory, clinical, or population studies into clinical applications"
NCI Translational Research Defined

National Cancer Institute Technical Working Group Definition
"Translational research transforms scientific discoveries arising from laboratory, clinical, or population studies into clinical applications to reduce cancer incidence, morbidity, and mortality."

NCI’s Translational Research Continuum

Basic Science Discovery
- Promising molecule or gene target
- Candidate protein biomarker
- Basic epidemiologic finding

Early Translation
- Partnerships and collaboration (academia, government, industry)
- Intervention development
- Phase III Trials

Late Translation
- Phase III Trials
- Regulatory approval
- Partnerships
- Production & commercialization
- Phase IV trials – approval for additional uses
- Payment mechanism(s) established to support adoption
- Health services research to support dissemination and adoption

Dissemination
- (new drug assay, device, behavioral intervention education materials, training)
  - To community health providers
  - To patients and public

Adoption
- Adoption of advancement by providers, patients, public
- Payment mechanism(s) in place to enable adoption

From the President's Cancer Panel 2004-2005 Report Translating Research into Cancer Care: Delivering on the Promise

“Public Health Informatics has been defined as the systematic application of information and computer science and technology to public health practice.”

Translational research in public health informatics is the conversion of advancements made in information and computer science into tools and applications to support public health practice.


“Public Health Informatics has been defined as the systematic application of information and computer science and technology to public health practice.”
Translational research in public health informatics is the translation of advancements made at the intersections of information technology, mathematics, and epidemiology into tools and applications to support public health practice.
A (proposed) Public Health Informatics Translational Research Continuum

- Basic Science Discovery
- Public Health Technology Requirement
- Early Translation
- Late Translation
- Dissemination
- Adoption
A Public Health Informatics Translational Research Continuum

Basic Science Discovery
- Computer Science
- Epidemiology
- Mathematics
- BioStatistics
- Physics
- etc.

Public Health Technology Requirement

Early Translation

Late Translation

Dissemination

Adoption
A Public Health Informatics Translational Research Continuum

Basic Science Discovery
- Computer Science
- Epidemiology
- Mathematics
- BioStatistics
- Physics
- etc.

Public Health Technology Requirement
- Disease surveillance & outbreak management

Early Translation
- Evaluate effectiveness of health care services
- Inform & educate on health issues
- etc.

Late Translation

Dissemination

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- Disease surveillance & outbreak management
- Evaluate effectiveness of health care services
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- etc.

Early Translation
- etc.

Late Translation
- Federal, local health agencies academia & industry
- Business & operational practices identified
- etc.

Dissemination

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Early Translation
- Federal, local health agencies academia & industry
- Business & operational practices identified
- etc.

Late Translation
- Application development thru iteration with collaborators
- Retrospective evaluation
- Prospective evaluation in operational environment
- etc.

Dissemination

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- etc.

Dissemination
- Knowledge sharing, publications & presentations
- Application open sourced
- Blogs, communities of practice
- etc.

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Adoption
- Adoption into business practice
- Discovery thru routine operations
- Knowledge sharing
- New requirements identification
- etc.
A Public Health Informatics Translational Research Continuum

Feedback needed to maintain relevancy
1. Background of the Surveillance Informatics Program at JHU/APL

2. Some Basis for Additional Surveillance Research & Development

3. Center of Excellence Sample Projects
Surveillance Project Beginnings at JHU/APL

- Basic Science Discovery
  - Computer Science
  - Epidemiology
  - Mathematics
  - BioStatistics
  - Physics
  - etc.

- Public Health Technology Requirement
  - Disease surveillance & outbreak management
  - Evaluate effectiveness of health care services
  - Inform & educate on health issues
  - etc.

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  - etc.

- Late Translation
  - etc.

- Dissemination

- Adoption
Identification of a Requirements for a Public Health Informatics Solution for Automating Disease Surveillance

1997–1998

Surveillance Requirements

Technical Approaches

Maryland DHMH

Johns Hopkins APL
Event Driven Requirement for an Operational Prototype


Surveillance Requirements

Maryland DHMH

Technical Approaches

Johns Hopkins APL

Y2K Surveillance
Early Indicators Used for Automated Surveillance

Surveillance Requirements
- Maryland DHMH

Technical Approaches
- Johns Hopkins APL

Y2K Surveillance
- Electronic Billing ICD-9
- Hospital ICP Reports
- Military Data
- Over-the-Counter Meds
- Nursing Homes
- School Absentee Reports
Y2K Sponsorship


Surveillance Requirements

Maryland DHMH

Technical Approaches

Johns Hopkins APL

DARPA Seed Funding

Y2K Surveillance
Electronic Billing ICD-9
Hospital ICP Reports
Military Data
Over-the-Counter Meds
Nursing Homes
School Absentee Reports
Expanded Collaborations


Surveillance Requirements

- Maryland DHMH

Technical Approaches

- Johns Hopkins APL

- DARPA Seed Funding

Michael Lewis
Prev. Med. Residency
ESSENCE in the NCR

Y2K Surveillance
Electronic Billing ICD-9
Hospital ICP Reports
Military Data
Over-the-Counter Meds
Nursing Homes
School Absentee Reports
Early ESSENCE Architecture
Electronic Surveillance System for the Early Notification of Community-based Epidemics

Hospitals
- Electronic Medical Records Capture
- ER Log
- Automated Surveillance Query
- ER Chief Complaint

Secure FTP Site
- Hospital Archive
- Hosp. Dir.
- Encrypted Transfer

Local Surveillance System
- Outbreak Detection Algorithms
- Data Sharing Policies
- Text Parsing Processes

Users
- Encrypted E-Mail
- State Health Dept.
- County Health Dept.

Participating Hospitals
- Sufficiently De-Identified Data Elements
- Sufficiently Anonymous Data Elements
A Public Health Informatics Translational Research Continuum

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- Dissemination
- Adoption
Surveillance Collaborations Provide Adoption & Basis for New Surveillance Functionality

Moving Across the Continuum Through Operational Experiences During 9/11 and the Anthrax Letters
Surveillance Collaborations Provide Adoption & Basis for New Surveillance Functionality

Operational Experiences for the Continuum

Seedling

BioAlirt

JSIPP

Maryland DHMH

Virginia DOH

DoD GEIS/WRAIR

Camp Lejeune, NC

Pope AFB, NC

Barksdale AFB, LA

Ft. Campbell, KY

Ft. Gordon, GA

San Diego, CA

Ft. Lewis, WA

Dahlgren, VA

Robins AFB, GA

Y2K Regional Surveillance

Regional Collaborations

Time
On January 6, 2005, two freight trains collided in Graniteville, South Carolina (approximately 10 miles northeast of Augusta, Georgia), releasing an estimated 11,500 gallons of chlorine gas, which caused nine deaths and sent at least 529 persons seeking medical treatment for possible chlorine exposure.
Location of Medical Facilities
Collecting Data for JSIPP During the Accident
Residence of Patients Seen at Local Hospitals In the Respiratory Syndrome

Learning Opportunities and Feedback into the Continuum
Surveillance Collaborations Provide Adoption & Basis for New Surveillance Functionality

Seedling
Maryland DHMH

BioAlirt
Maryland DHMH
Virginia DOH
DC DOH
DoD GEISWRAIR

JSIPP
Camp Lejeune, NC
Pope AFB, NC
Barksdale AFB, LA
Ft. Campbell, KY
Ft. Gordon, GA
San Diego, CA
Ft. Lewis, WA
Dahlgren, VA
Robins AFB, GA

BioWatch
Veterans Health Admin.
Washington DoH
Santa Clara DoH
Missouri DoH
Marion Co. DoH
LA County DoH
Cook Co. DoH
Tarrant Co. DoH
Miami DoH
Milwaukee DoH

Y2K
Regional Surveillance

Regional Collaborations
Regional Collaborations
Wealth of Feedback

Time

Lombardo 01/28/09
| 1. | Improvement in Performance of Ngram Classifiers with Frequency Updates, P. Brown et al. |
| 13. | Utilizing Emergency Department Data to Evaluate Primary Care Clinic Hours, J. Lincoln, et al. |
Feedback into the Continuum Through Operational Experiences

Basic Science Discovery
- Computer Science
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Dissemination
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- etc.

Adoption
- Adoption into business practice
- Discovery thru routine operations
- Knowledge sharing
- New requirements identification
- etc.

Feedback needed to maintain relevancy
1) Syndromic groupings create performance constraints
1) Are syndrome groupings the best way to perform surveillance?

**ICD-9 Based**

- 038.8  Septicemia NEC
- 038.9  Septicemia NOS
- 066.1  Fever, tick-borne
- 066.3  Fever, mosquito-borne NEC
- 066.8  Disease, anthrop-borne viral NEC
- 066.9  Disease, anthrop-borne viral NOS
- 078.2  Sweating fever
- 079.89 Infection, viral NEC
- 079.99 Infection, viral NOS
- 780.31 Convulsions, febrile
- 780.6  Fever
- 790.7  Bacteremia
- 790.8  Viremia NOS
- 795.39 NONSP POSITIVE CULT NEC

**Syndrome**

- Botulism-like
- Febrile Disease
- Fever
- Gastrointestinal
- Hemorrhagic
- Neurological
- Rash
- Respiratory
- Shock / Coma

**Chief Complaint Based**

- Chills
- Sepsis
- Body Aches
- Fatigue
- Malaise
- Fever Only
Feedback into the Continuum
Limitations of Existing Syndromic Surveillance

1) Syndromic groupings create performance limitations
Feedback into the Continuum
Limitations of Existing Syndromic Surveillance

1) Syndromic groupings create performance limitations
   • Large groups create a noisy background level
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   • Large groups create a noisy background level
   • Signals must be strong enough to be distinguished above the background
1) **Syndromic groupings create performance limitations**
   - Large groups create a noisy background level
   - Signals must be strong enough to be distinguished above the background
   - Fixed number of predefined syndromes limit system usefulness for discovery of immediate health risk
Changing Environment for Public Health Surveillance & Its impact on Performance

Existing Surveillance Focus

Data Containing Health Risk Indications
- ED Chief Complaint
- ICD-9
- OTC Meds

Health Information Exchanges
- Early Event Detection
- Health Department’s Syndromic Surveillance System

Non Specific Data Sources

Health Information Exchanges
- Public Health Agency Surveillance
- Public Health Situational Awareness

Electronic Medical Records

- Health Information Exchanges
- Electronic Medical Records

- Health Information Exchanges
- Electronic Medical Records

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- Electronic Medical Records

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- Health Information Exchanges
- Electronic Medical Records

- Health Information Exchanges
- Electronic Medical Records
Accessing Linked Medical Records for Public Health Situational Awareness

Effective use of the Electronic Medical Record Enables Situational Awareness
Feedback into the Continuum
Limitations of Existing Syndromic Surveillance

1) Syndromic groupings create performance limitations
   • Large groups create a noisy background level
   • Signals must be strong enough to be distinguished above the background
   • Fixed number of predefined syndromes limit system usefulness for discovery of immediate health risk

2) Effective utilization of multiple data streams
Adding data sources increases the statistical false positives
Current Disease Surveillance Analytics Approach

Alerting & Notification for a Syndrome or Disease

Detection of Abnormal Levels for a Syndrome

Temporal Algorithms
Spatial Algorithms

Temporal Algorithms
Spatial Algorithms

Temporal Algorithms
Spatial Algorithms

ED Chief Complaints
OTC Medication Sales
Lab Requests / Results

Alert Fatigue

Adding data sources increases the statistical false positives
Feedback into the Continuum
Limitations of Existing Syndromic Surveillance

1) Syndromic groupings create performance limitations
   • Large groups create a noisy background level
   • Signals must be strong enough to be distinguished above the background
   • Fixed number of predefined syndromes limit system usefulness for discovery of immediate health risk

2) Effective utilization of multiple data streams
   • Clinical findings are most relevant on the individual patient level
1) Syndromic groupings create performance limitations

   • Large groups create a noisy background level
   • Signals must be strong enough to be distinguished above the background
   • Fixed number of predefined syndromes limit system usefulness for discovery of immediate health risk

2) Effective utilization of multiple data streams

   • Clinical findings are most relevant on the individual patient level
   • Creates additional false positives if the relationships among the data streams aren't known and included in the algorithms
Feedback into the Continuum
Limitations of Existing Syndromic Surveillance

1) Syndromic groupings create performance limitations
   • Large groups create a noisy background level
   • Signals must be strong enough to be distinguished above the background
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2) Effective utilization of multiple data streams
   • Clinical findings are most relevant on the individual patient level
   • Creates additional false positives if the relationships among the data streams aren’t known and included in the algorithms

3) Data and information sharing
Must accommodate the sharing of data and information
Feedback into the Continuum
Limitations of Existing Syndromic Surveillance

1) Syndromic groupings create performance limitations
   - Large groups create a noisy background level
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2) Effective utilization of multiple data streams
   - Clinical findings are most relevant on the individual patient level
   - Creates additional false positives if the relationships among the data streams aren’t known and included in the algorithms

3) Data and information sharing
   - HIPAA and identity theft have placed limitations on data sharing among public health agencies
   - State laws restrict sending data captured for surveillance purposes outside state boundaries
Information Must Be Shared Among Public Health and Health Care Systems

Health Information Exchanges

- Hospital A
- Hospital B
- Hospital C
- Urgent Care Clinic
- HMO
- Physician’s Group A
- Physician’s Group B
- Public Health Agency Surveillance
- Public Health Situational Awareness

Electronic Medical Records
Feedback into the Continuum
Limitations of Existing Syndromic Surveillance

1) Syndromic groupings create performance limitations
   - Large groups create a noisy background level
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2) Effective utilization of multiple data streams
   - Clinical findings are most relevant on the individual patient level
   - Creates additional false positives if the relationships among the data streams aren’t known and included in the algorithms

3) Data and information sharing
   - HIPAA and identity theft have placed limitations on data sharing among public health agencies
   - State laws restrict sending data captured for surveillance purposes outside state boundaries
   - Healthcare delivery must be aware of public health concerns
   - **Information to support public health surveillance information should be obtained during patient encounters**
Current Feedback Paths Into the Translational Research Continuum

Feedback needed to maintain relevancy

Basic Science Discovery
- Computer Science
- Epidemiology
- Mathematics
- BioStatistics
- Physics
- etc.

Public Health Technology Requirement
- Disease surveillance & outbreak management
- Evaluate effectiveness of health care services
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Early Translation
- Federal, local health agencies academia & industry
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- etc.

Late Translation
- Application development thru iteration with collaborators
- Retrospective evaluation
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- etc.

Dissemination
- Knowledge sharing, publications & presentations
- Application open sourced
- Blogs, communities of practice
- etc.

Adoption
- Adoption into business practice
- Discovery thru routine operations
- Knowledge sharing
- New requirements identification
- etc.
Operationally Identified Surveillance Requirement:

1) Ability to perform surveillance for specific populations by performing advanced queries on linked clinical data from medical records.

2) Ability to create rules to customize the detectors for the specific populations or events being monitored.

3) Informatics tools are needed that permit epidemiologists and disease monitors to create new surveillance objects without enlisting the support of IT system specialists.

4) Health risks must be shared between health care and other public health agencies.
Current Disease Surveillance Analytics Approach

Detection of Abnormal Levels for a Syndrome

- Temporal Algorithms
- Spatial Algorithms

Alerting & Notification for a Syndrome or Disease

- Temporal Algorithms
- Spatial Algorithms

ED Chief Complaints

OTC Medication Sales

Lab Requests / Results

Alerting

Adding data sources increases the statistical false positives

Alert Fatigue

Lombardo 01/28/09
Moving from Syndromic to Case Specific Surveillance in a Collaborative Environment

Patient Care Delivery
- Phone Triage
- Chief Complaint
- Clinic Notes
- Medications
- Lab Requests & Results
- Radiology Requests & Reports
- ICD-9 & CPT Codes

EMR

Medical Record

HIE

Health Information Exchange

Local Public Health Agency
- Newer Version of an Automated Surveillance System
- Information Sharing
- Flexible Alert Criteria
- Advanced Query Tool or Filter

Health Care & Other PH Agencies
- Collaborative Sharing of Surveillance Results

Population Specific Analysis
- Epidemiologist Initiated Modifications

Health Care Delivery
Sample Project 1: Advanced Query Tool, AQT
Analysis of user defined subpopulations

Query 1: Syndrome based

Query 1 = Syndrome Respiratory

Query 2: Chief complaint (CC) free-text

Query 2 = CC cough* + CC fever*

Query 3: Logical combinations that mix all stratifications (chief complaint, syndrome, etc)

Advanced Query 3 = Age 0 - 4 + Syndrome GI + CC cough* + Age 18 - 64 + Lab Confirmed Flu

or
Advanced Query Tool Project

• Ability to include all the data elements that are available to the surveillance system in the query

• Hide the complexity of the underlying data models and query languages

• Allow users to build on-the-fly case definitions using any data element available.
Advanced Query Tool

Data Source: Emergency Room

Query:

\(((\text{SUBSYNDROME} = \text{"AbdominalCramps"}) \text{ OR } (\text{SUBSYNDROME} = \text{"AbdominalPain"})))

Example: \([\text{AGE} > \text{"33"}] \text{ OR } ((\text{SUBSYNDROME} = \text{"ACUTE BLOOD ABNORMALITIES"}) \text{ AND } (\text{ZIPCODE} = \text{"21043"})))\n
Query Builder

Group multiple selections with: OR AND
Further Information on AQT


Sample Project 2: My Alerts

• The ability for a user to generate on-the-fly case definitions lead to the need for those dynamic queries to become part of the health department’s day-to-day detection system.

• In addition, because these very specific streams are well understood, specific detection criteria may be required for each individual query.

• myAlerts allows users to save any query, and define exact requirements for an alert to be generated. This may be temporal detection related (threshold for red/yellow alerts, minimum count, # of consecutive days alerting, etc), or can also be flagged as “Records of Interest” in which case any patient seen that matches the query will be alerted on.
myAlert Results

Detection based myAlerts

Records of Interest based myAlerts
Additional information on My Alerts


## Sample Project 3: *Infoshare*

**Overcoming Data Sharing Obstacles**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Epi Interpretation</strong></td>
<td>Epi: “Respiratory outbreak we are currently investigating”</td>
</tr>
<tr>
<td><strong>Multivariate Analysis</strong></td>
<td>Fusion Detector: Respiratory has a Red Alert across 3 of 5 sources</td>
</tr>
<tr>
<td><strong>Univariate Analysis</strong></td>
<td>Detector: ER Respiratory visits are 4 times the normal rate</td>
</tr>
<tr>
<td><strong>Aggregated Data</strong></td>
<td>247 ER Respiratory visits, 1647 OTC Respiratory products sold</td>
</tr>
</tbody>
</table>
| **Cleansed Data** | John Doe, 26, M, Sore Throat  
Jane Doe, 20, F, Shortness of Breath ... |
| **Raw Data** | John Doe, 26, M, Sore Throat  
John Doe, 26, M, Sore Throat  
Jane Doe, 1987, Female, SoB ... |
Information Exchange Concept

Information Sharing Exchange

Epidemiological Interpretations

Local Disease Surveillance

Epidemiological Interpretations

Local Disease Surveillance
Information Sharing on the Grid
Infoshare Used for the Inaugural NCR Regional Collaboration

NCR Disease Surveillance Network

Bio Intelligence Center

Aggregated NCR ESSENCE

Over the Counter Sales

Hospital EDs

District of Columbia

EsSENCE

Infoshare Website

Hospital EDs

Maryland ESSENCE

Virginia

Hospital EDs
## Inaugural *Infoshare* Site

### Event List Grid

<table>
<thead>
<tr>
<th>Concern Level</th>
<th>Title</th>
<th>Author</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring</td>
<td>Higher than normal admission of fever patients</td>
<td>jbrown</td>
<td>10/03/2006</td>
<td>10/04/2006</td>
</tr>
<tr>
<td>Investigating</td>
<td>Higher than normal fever rate continues</td>
<td>jbrown</td>
<td>10/04/2006</td>
<td>10/05/2006</td>
</tr>
</tbody>
</table>

### Edit Event | Add Comment

<table>
<thead>
<tr>
<th>ID</th>
<th>Date of Event</th>
<th>Author</th>
<th>Concern Level</th>
<th>Syndrome</th>
<th>Title</th>
<th>Age Group</th>
<th>Sex</th>
<th>Size of Event</th>
<th>Excess Cases</th>
<th>Geographic Spread</th>
<th>State</th>
<th>County</th>
<th>Name</th>
<th>Phone #</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10/03/2006</td>
<td>jbrown</td>
<td>Monitoring</td>
<td>Fever</td>
<td>Higher than normal admission of fever patients</td>
<td>18-44</td>
<td>Female</td>
<td>1000's</td>
<td>100's</td>
<td>Localized</td>
<td>DC</td>
<td>Washington, DC</td>
<td>Jane Brown</td>
<td>555-555-5555</td>
</tr>
</tbody>
</table>

In the last three hours, an abnormally high number of patients have been admitted to the ER with extremely high fever. Will continue to monitor for updates.

### Comments:

<table>
<thead>
<tr>
<th>ID</th>
<th>Last Modified</th>
<th>Author</th>
<th>Concern Level</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>11/17/2008 03:26:26 PM</td>
<td>aryan</td>
<td>Information</td>
<td>No increased fever rate detected in Loudoun</td>
</tr>
</tbody>
</table>

We have reviewed our admission rates for the last twelve hours and have not noticed any increased admission rate for fever in Loudoun county. We will continue to
Linkage within ESSENCE to *Infoshare*

New Share Button added to myAlerts.
This allows users to create InfoShare messages directly from ESSENCE with most message fields pre-filled out.
CDC EMR Alerting Concept Diagram Alerting Data Flow v15
DRAFT

Public Health Monitoring

Condition for Alert Identified/Coded (SNOMED, LOINC)

Create PH Alert (Based on message specifications)

Alerting Transport System Sends Message

Message sits on a standalone knowledge repository or on a PH grid.

Knowledge Repository
INFOSHARE

Case Archive

Context/content matching profiles

Monthly Quality Report

Message Receipt Confirmation

Providers Seeing Patients

As part of their workflow, providers poll for messages when seeing patients and click the info button for more detail.

Receive

EMR applies decision support algorithms to retrieve appropriate PH messages

Request

Courtesy Nedra Garrett, CDC
Additional Information on InfoShare


Is this the Correct Translational Research Continuum for Public Health Informatics?

![Diagram showing the translational research continuum with stages for Basic Science Discovery, Public Health Technology Requirement, Early Translation, Late Translation, Dissemination, and Adoption. Each stage includes specific activities and feedback needed to maintain relevance.]

- **Basic Science Discovery**
  - Computer Science
  - Epidemiology
  - Mathematics
  - BioStatistics
  - Physics
  - etc.

- **Public Health Technology Requirement**
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  - Knowledge sharing, publications & presentations
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- **Adoption**
  - Adoption into business practice
  - Discovery thru routine operations
  - Knowledge sharing
  - New requirements identification
  - etc.

Feedback needed to maintain relevancy.
JHU/APL COE Team

**Computer Science**
- Raj Ashar MA
- Mohammad Hashemian MS
- Logan Hauenstein MS
- Charles Hodanics MS
- Joel Jorgensen BS
- Wayne Loschen MS
- Zarna Mistry MS
- Rich Seagraves BS
- Joe Shora MS
- Nathaniel Tabernero MS
- Rich Wojcik MS

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