



USING SEVERITY INFORMATION TO BRIDGE THE GAP BETWEEN STATISTICS AND EPIDEMIOLOGY

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Project Premises and Objective

Current reality of ESSENCE monitoring:

Excessive nonspecific alerting in some contexts

Mainly staff monitors too much with too little information

New data sources will make more clinical details available, *but*

Already reluctant users cannot be expected to do the integration and weighting

ESSENCE must become simpler to use, not more complex

Develop analysis methods that will allow more efficient monitoring of ESSENCE data sources


- to gain advantage of various specific evidence types
- analysis + visualization to enable monitoring without confusion

First phase: use information in outpatient clinic record fields to enhance routine surveillance


- reduce volume of algorithm alerts
- but retain sensitivity to events of public health importance
- show only severity-related alerts as default

Second phase: Extend alerting criteria to include information from more recently acquired data sources

- as data are understood and criteria are developed



Evolution of Data


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Standard Ambulatory Data Record(SADR)						
ID	visit date	icd9 (up to 4)	cpt(e&m + up to 5)	disp	installation	clinic
123456	1/1/2007	486.0	87070	1	0117	BIAA

O
L
D


CAPER (Comprehensive Ambulatory and Professional Data Record (replaces SADR))						
ID	visit date	icd9(up to 10)	Same as Above	+	Chief Complaint	
123456	1/1/2007	486.0			Flu, Sore Throat	

N
E
W


ASADR Lab & Rad					
ID	order date	cpt	installation	clinic	
123456	1/1/2007	87070	0117	BIAA	
123456	1/1/2007	71022	0117	BIAA	

Microbiology , Chemistry and Hematology Test Results					
ID	order date	cpt	installation	clinic	
123456	1/1/2007	87070	0117	BIAA	
Test Order Name	result date	Test Result			
Respiratory Culture	1/2/2007	Flu A Negative			

PDTs					
ID	date presc.	date filled	DrugName	gc3	Clinic, Installation, etc..
123456	1/1/2007	1/1/2007	Tamiflu 75 ml gelcap	W5A	



Data Fields Containing Severity Information in SADR data


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- Diagnostic Codes(ICD9)
- Clinic Code(MEPRS)
- Procedure Codes(CPT)
- Disposition Codes
 - Admitted, Dead , Referred
- Evaluation and Management Codes(Part of CPT)
 - High Complexity, High Severity, Transported to the Hospital
- Indirect: Bounce-backs, Type of Facility



Defined Tiers of Service

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- Tier 1: hospitals or large treatment centers with a full range of services for all ages
 - WRAMC, NMMC, Wilford Hall, NH Camp Pendleton, etc.
- Tier 2: treating mainly adult populations and reduced critical care capability
 - Barquist Army Health Clinic, 579th MedGrp, etc.
- Tier 3: no inpatient services or emergency clinic and almost all patients in the active duty age range
 - MCRDs, Ft Dix Troop Clinic, Dilorenzo Clinic, etc.



Phase I: Severity Series using Outpatient Visit Records

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In addition to statistically significant rise,
anomalous rise in one of:

- Cases admitted or deceased (or in small facilities, referred)
- Severe EM Codes (moderate for emergency clinics)
- “Bounce-backs” returning with similar complaints within 72 hours
- Young children or elderly relative to usual distribution for facility type

Or an unusually steep rise in visits (e.g. over twice the threshold level)



Implementing Severity Criteria

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- Applied adaptive control charts to daily counts of severity indications as well as to the syndromic visit counts
- Chose control chart according to tier of service
- A severity-associated alert was an alert based on syndromic visit counts on the same day that one of the severity criterion charts flagged
- Used the p-chart for a criterion based on anomalous proportions of patients under age 18 yrs



Validation of Alert Filtering

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- Code sets of severity criteria
- Import datasets with outbreak effects in patient records
- Apply criteria to separate datasets for outbreak detection sensitivity and timeliness
- Rank criteria according to
 - Robustness of sensitivity across test data
 - Reduction in background alert rate



Severity Criteria Example



Severity Columns																		
Date	count	= 1 for alert	EMCOUT	EMCER	EMCIN	AdmDead	Referral	Preschool	SchoolAge	Adult	Elderly	Bouncebacks	Cond. 1: EM	Cond. 2: Disp.	Cond. 3	Cond. 4	Cond. 5	Severity Flag
06/18/07	8	1	0	0	0	0	0	0	0	8	0	0	0	0	0	1	0	1
06/19/07	8	1	1	0	0	0	0	0	0	8	0	3	0	0	1	1	0	1
06/22/07	7	1	1	0	0	0	0	0	0	7	0	2	0	0	1	0	0	1
01/05/08	4	1	1	0	0	0	0	0	0	4	0	0	1	0	0	0	0	1
01/07/08	6	1	1	0	0	0	0	0	0	6	0	3	0	0	1	1	0	1
02/16/08	6	1	0	0	0	0	0	0	0	6	0	2	0	0	1	1	0	1
02/19/08	4	1	0	0	0	0	0	0	0	4	0	2	0	0	1	0	0	1

Figure 14: Criterion detail (as in Fig. 4) for alerts associated with severity in 540 days of data including the norovirus outbreak at San Diego NMRCB beginning in mid-June, 2007.



Outbreak Test Datasets



Dataset	Type of Outbreak	Dates
San Diego	Group A Strep Pneumonia	Nov-Dec 2002
	Febrile Respiratory	mid-Aug -- Dec. 2003
Ft. Dix	Norovirus	Dec. 2006
Lackland AFB	Adenovirus	beginning Feb 2007, peaking May 27--June 2
	Influenza	Feb-March 2007
Parris Island	acute febrile illness	Jun. - Oct. 2007
San Diego MCRD	Norovirus	Jun. 2007
D.C. Region	Influenza	Nov. - Mar. 2008

(From open literature)



Effect of Severity Criteria on Alerting in Outbreak Datasets



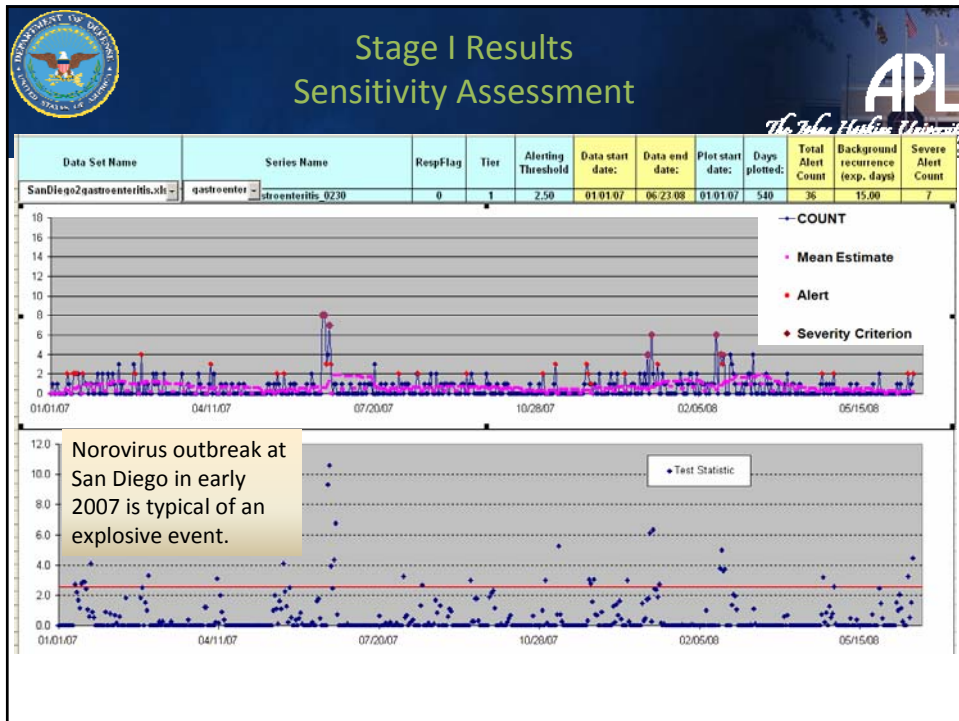
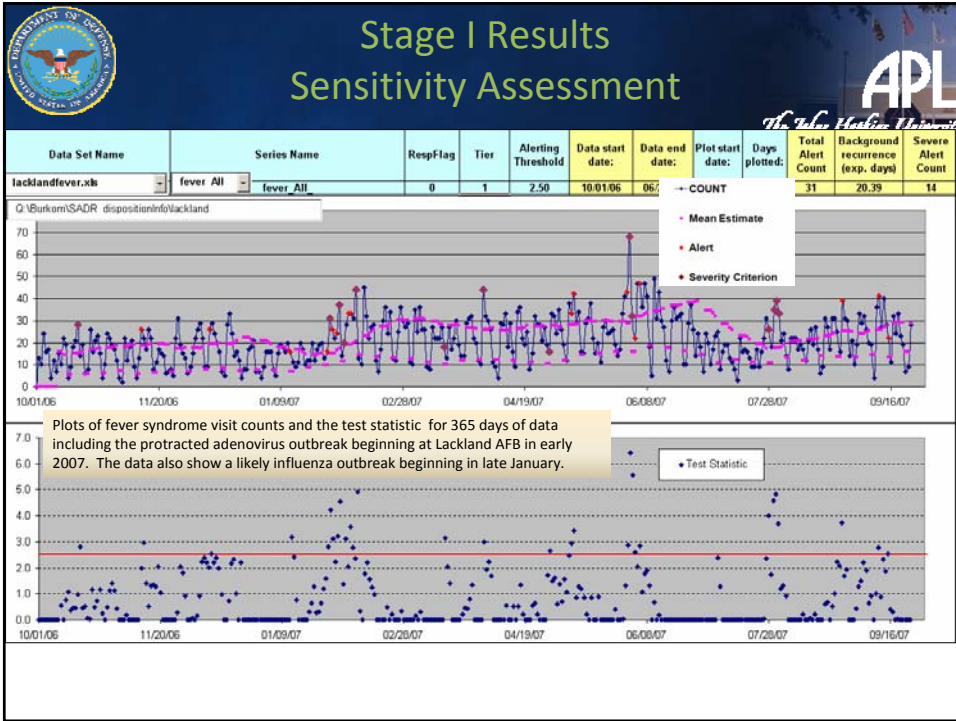
Facility or All	total no. of days	mean data count	total alert count	alert with severity	cond. 1 (with alert)	cond. 2 (with alert)	cond. 3 (with alert)	cond. 4 (with alert)	cond. 5 (with alert)
Small Region, Fever									
All	540	5.6	47	20	13 (6)	1 (1)	11 (4)	17 (13)	4 (1)
MTF 1	540	2.7	51	18	7 (5)	1 (1)	0 (0)	11 (10)	18 (4)
MTF 2	540	2.8	43	14	5 (2)	0 (0)	9 (3)	13 (11)	0 (0)
MTF 3	540	0.1	16	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
San Diego, GI									
All	540	12.2	44	21	26 (12)	5 (0)	8 (5)	21 (8)	1 (0)
MTF1	540	0.6	40	5	0 (0)	0 (0)	2 (2)	5 (5)	0 (0)
MTF2	540	2.5	42	9	4 (4)	0 (0)	1 (0)	5 (3)	8 (0)
MTF3	540	5.4	38	11	13 (5)	4 (0)	1 (1)	18 (6)	13 (1)
MTF4	540	0.1	22	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MTF5	540	1.3	21	2	1 (1)	0 (0)	0 (0)	4 (1)	0 (0)
MTF6	540	0.6	23	0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MTF7	540	0.7	28	2	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MTF8	540	0.7	33	1	1 (0)	0 (0)	0 (0)	2 (1)	1 (1)
San Antonio, Fever									
All	365	14.1	42	26	49 (14)	56 (10)	29 (10)	12 (5)	23 (1)

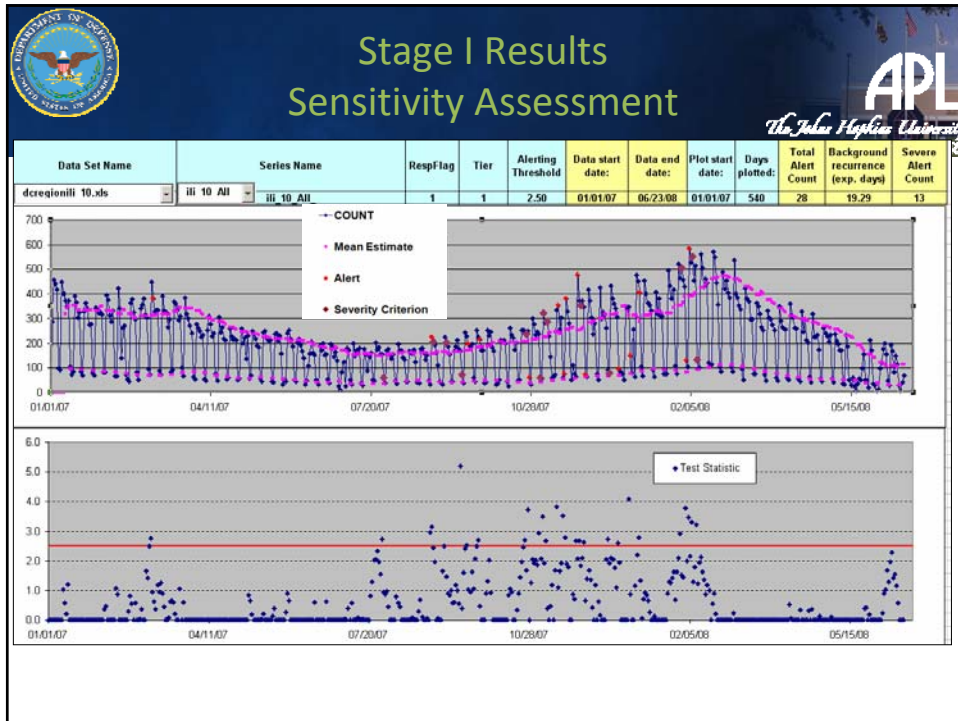


Severity Criteria Effect on ILI Alerting: Typical NCR seasonal febrile resp. illness





Facility or All	total no. of days	mean data count	total alert count	alert with severity
DC Region, ILI_10				
All	540	201.2	34	16
Facility 1	540	25.4	35	22
Facility 2	540	26.1	35	13
Facility 3	540	35.4	36	22
Facility 4	540	11.0	24	10
Facility 5	540	21.1	17	7
Facility 6	540	43.5	35	10
Facility 7	540	0.5	29	3
Facility 8	540	6.6	12	3
Facility 9	540	1.4	17	2
Facility 10	540	3.9	20	5
Facility 11	540	8.2	13	2
Facility 12	540	8.2	12	4





Summary of Applying a Severity-based Filter in ESSENCE

- In some of the smaller facilities, no alerts associated with severity were seen, and the severity filter could make investigation of alerts manageable for multiple syndrome groupings with limited time for monitoring
- The filter method also reduces alerts for larger facilities, and with the diagnostic services available at these, the additional datasets are likely to provide further improvement in specificity
- The criteria reduce the number of alerts without losing sensitivity to known outbreaks
 - Three of the test scenarios showed a 1-day loss of timeliness, while the others showed no loss
 - The alert reduction is dramatic in datasets from small facilities, often reducing the alert rate from 20 per year to below 5
- Severity approach encourages routine investigation
 - by reducing the number of alerts,
 - also by limiting attention to alerts likely connected with serious illness,
 - with readily accessible information on type of severity



Phase 2 Premises



- Advances in DoD health information technology allow ESSENCE to access a wealth of information concerning each individual health care encounter
- For example, laboratory test orders and results, prescriptions, and vital signs can be linked to individual patient records
- We should be able to better categorize visits into appropriate syndromes AND estimate the severity of the visit with a high degree of accuracy
- Goal: combine statistical aberration detection and clinical knowledge according to available data characteristics to display anomalies with viewable criteria indicating that they are epidemiologically relevant, i.e., should not be ignored



Phase II: Strategy for Combining Evidence Driven by Clinical Experience



Consider all cases in syndromic grouping every day

- Each case: gather all linked data corresponding to current problem.
 - Deaths/Admissions/VSI (very seriously ill, like shock/coma)
 - Number of tests ordered (not procedures)
 - Presence of certain tests by syndrome
 - Look for indicators of acute illness
 - For each such test, seek corroborating tests. (e.g. arterial blood gas)
 - Relate test results to age group, data fields indicating co-morbidities
 - Assign a weight, with thresholds depending on syndrome.
- Gather cases of concern, calculate measure of disease burden, weighted by severity—form severity score for each syndrome/day
- Show daily syndrome disease burden using visualization tools
 - Showing rationale for severity
 - Allowing drill down for details



Linkage: Lab Tests and SADR Record



- Analyzed ≈ 2M regional patient visits in 2007
- Microbiology laboratory tests
 - 98% of the test result patient IDs matched SADR visit patient IDs
 - Of these matches, 90% of the tests were ordered the same day as the visit, and 97% were ordered within 1 week of the visit
- Chemistry laboratory tests
 - 92% of the test results matched to patient IDs in SADR visits
- Expanded linkage to all MTFs by patient ID and exact date; measured associations of individual tests with syndromic SADR visits

$$H_0 : p_1 = p_2 \text{ vs. } H_1 : p_1 \neq p_2$$

$$\text{Statistic} : \frac{p_1 - p_2}{\sqrt{\frac{p_1 \cdot (1 - p_1)}{m} + \frac{p_2 \cdot (1 - p_2)}{n}}}$$



Association of Microbiology Test Order Types with Respiratory Syndrome



Test Ordered	# Orders Associated With Resp Syndromic Visit	% Orders Associated With Resp Syndromic Visit	# Orders Associated With Any Visit	% Orders Associated With Any Visit	Statistic	Comment: 1=Associated with Syndrome; 2=Severity for a given Syndrome; 3=No Association
THR CULT	201243	41.04%	262775	6.96%	476.6	1
THROATCUL/GRP A	13234	2.70%	16316	0.43%	96.87	1
THROAT CULTURE	9912	2.02%	14173	0.38%	80.86	1
RESP CULT	21257	4.34%	88754	2.36%	65.68	1
RAPID STREP A	5637	1.15%	7310	0.19%	62.08	1
RAPID STREP	5367	1.09%	6854	0.18%	60.75	1
R/S CONFIRM	5067	1.03%	6666	0.18%	58.64	1
RESP VIRAL CUL	5191	1.06%	8140	0.22%	56.88	1
SPUTUM CULTURE	3715	0.76%	6403	0.17%	46.75	1
TC STREP	2780	0.57%	3618	0.10%	42.92	1



Phase II Severity Classifications

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- Level 1:
 - Any visit with a disposition of death
 - Visits with lab tests or procedures that are heavily associated with intensive care units
- Level 2:
 - Admissions to hospital from outpatient clinics
 - ER visits with moderate to severe E&M code or with immediate referral
 - Repeat ER visits within 72 hours
 - ER visit and # of lab tests > 3
 - ER visit and lab test associated with severity for that syndrome
- Level 3:
 - All other ER visits not captured above
 - Outpatient visits with moderate-severe E&M code or return in 72 hours
 - Lab test associated with severity for that syndrome
 - # of lab tests > 3
- Level 4: All other outpatient visits

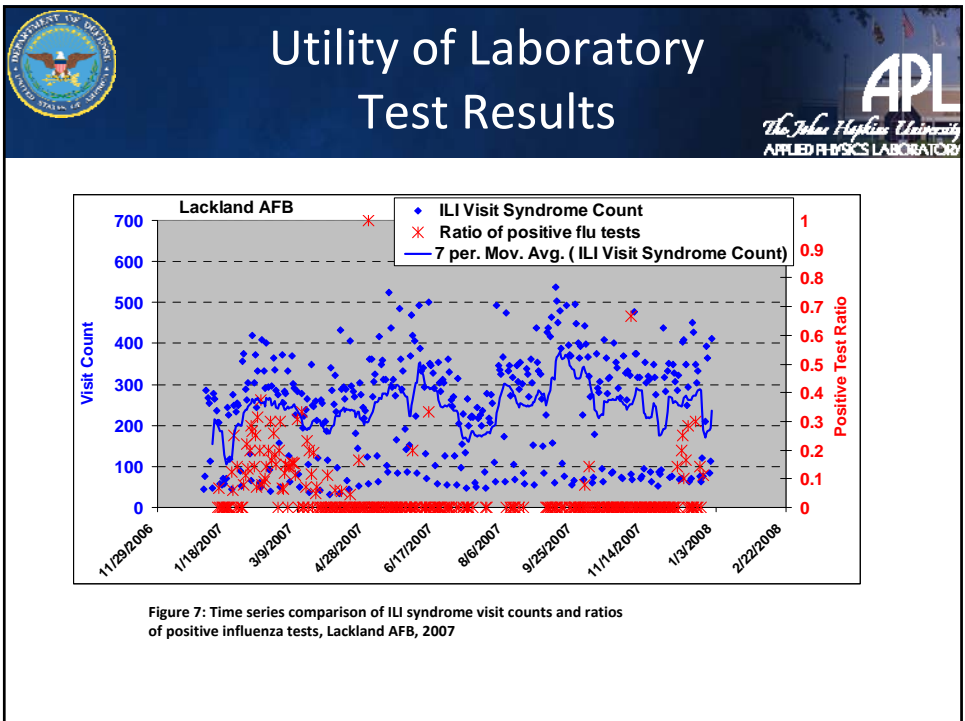
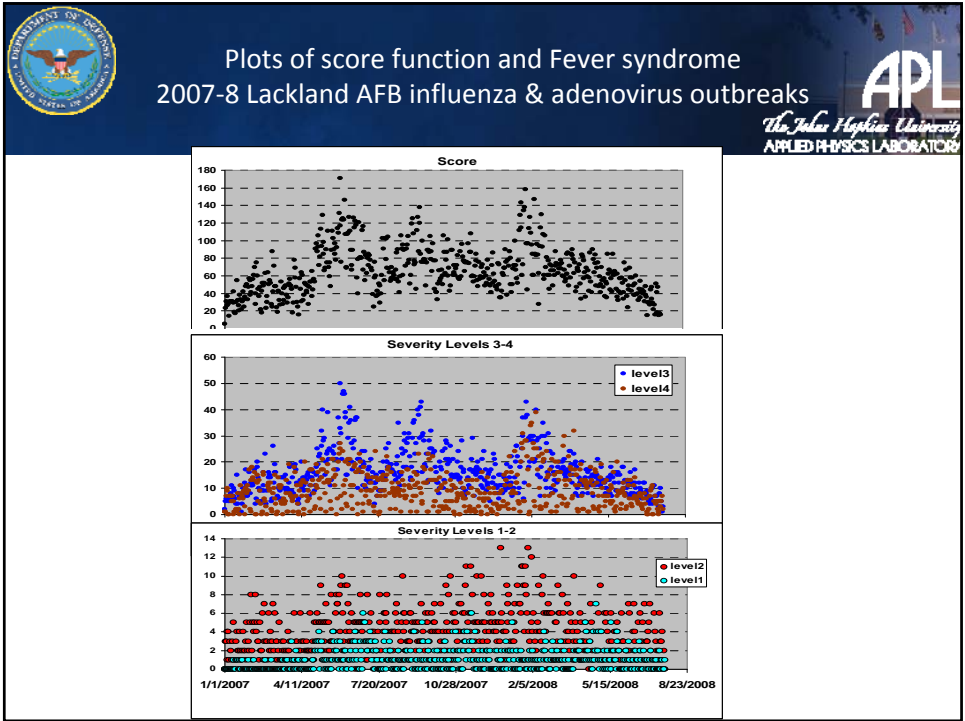


Phase II Discussion

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- Included all ESSENCE patient encounter records, not only those records that mapped (via ICD-9) to syndrome groupings
- Assembled linked patient records to form “cases,” whose combined information could be expressed as a severity score
 - Assigned severity level (1-4), based on clinical experience
 - Developed a *score function*, assigned exponential weights of 8, 4, 2, and 1 for levels 1, 2, 3, and 4, respectively
- Applied alerting methods to daily aggregate scores
- Looked at test results
- Results lacked specificity, suggesting
 - Underlying severity levels need further refinement
 - Exponential weighting need tweaking, especially for Severity Levels 1 & 2 (small number of cases)





Phase II: Summary and Next Steps



- Testing of the severity criteria with outbreak data was hampered by insufficient coverage and quality of the available data from linkable Block III data sources
- Of the set of outbreaks considered, only the Lackland AFB influenza and adenovirus events were well represented in multiple linkable data sources
 - The outbreak testing gave no information about the utility of the higher severity levels, and data from other outbreaks is needed to properly define and weight these levels
- Initial evaluation indicates that severity-related criteria with linked data sources (SADR, Lab Orders, etc.) can reduce the overall alert/alarm rate while maintaining detection timeliness and sensitivity
- Extend the evaluation
 - Create and test additional lab order categories
 - Additional known outbreaks
 - Optimize severity level definitions and exponential weighting
 - Evaluate visualization methods to maximize information extraction by ESSENCE users
- Embed the best practices into DoD ESSENCE



Questions?