SIDARTHa

European Emergency Data-based Syndromic Surveillance System

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EUROPEAN COMMISSION GEOMED RESEARCH UC UNIVERSIDAD DE CANTABRIA

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Evaluating SIDARTHa's performance: Syndromes, detection algorithms & a case study

Nicole Rosenkötter

Maastricht University I School for Public Health and Primary Care (CAPHRI) I FHML I Dept. International Health

Brussels, Belgium

SIDARTHa Open Conference

Roadmap

1. Case study - Influenza 2009
2. Data sources and syndrome definitions
3. Methods applied
4. Results
5. Summary

Influenza case study

Research questions:

1. Is the timeline (epidemic curve) of influenza-like illness generated by emergency medical care data (EMD, EMP, ED) in 2009 comparable to the epidemic curve of influenza cases registered by the surveillance system of the respective health authority?
2. How sensitive and specific is the SIDARTHa system? (E.g. Sensitvity: The ability of the SIDARTHa system to signal “real” increases of influenza-like illness)
3. How timely is the SIDARTHa system?

Overview used data sources

1. Dispatch Centre Tyrol (EMD) I Austria
2. Dispatch Centre Tyrol (EP) I Austria
   - Area: of the City of Innsbruck (118,035 inhabitants), the County of Innsbruck (164,027 inhabitants) and the District of Kufstein (99,394 inhabitants).
3. Klinik am Eichert, Göppingen (EP) I Germany
   - Data from the Emergency Physician Service of the County Göppingen (approx. 255000 inhabitants) in the region Baden-Württemberg.
4. University Hospital Leuven (ED) I Belgium
   - Leuven (approx. 91,000 inhabitants) – capital of the region Flemish Brabant (approx 1 million inhabitants).
5. University Hospital Santander (ED) I Spain
   - Santander (approx. 180,000 inhabitants) is the capital of the Autonomous Region Cantabria (approx. 590,000 inhabitants). The University Hospital serves a population of approx. 300,000 inhabitants.

AMPDS
Advanced Medical Priority Dispatch System

Respiratory syndrome

AMPDS v11.3

	6		**Breathing problems**	**Possible appendix (suffix) behind code**
C		1	Abnormal breathing	
C		2	Known heart disease	
D		1	Difficulty breathing	A. Asthma
D		2	Not alerting	
D		3	Sweating	
	26		**Sick person (specific diagnosis)**	
A		25	Sore throat (without difficulty breathing or swallowing)	

Since 5-1-2009 AMPDS v12.0

	6		**Breathing problems**	**Possible appendix (suffix) behind code**
C		1	Abnormal breathing	
D		1	Not alerting	
D		2	Difficulty in breathing between breaths	A. Asthma
D		3	changing colour	
D		4	clammy	
	26		**Sick person (specific diagnosis)**	
A		4	Fever/chills	
O		26	Sore throat (without difficulty breathing or swallowing)	

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Influenza-like illness - ICD-10

J00	Acute nasopharyngitis [common cold]
J02	Acute pharyngitis (includes sore throat)
J04	Acute laryngitis and tracheitis
J05.0	Acute obstructive laryngitis [croup]
J05.1	Acute epiglottitis
J06	Acute upper respiratory infections of multiple and unspecified sites
J09	Avian Influenza
J10	Influenza due to other identified influenza virus
J11	Influenza, virus not identified
J15	Bacterial pneumonia, not elsewhere classified
J16	Pneumonia due to other infectious organisms, not elsewhere classified
J17	Pneumonia in diseases classified elsewhere
J18	Pneumonia, organism unspecified
J22	Unspecified acute lower respiratory infection
J96.0	Acute respiratory faillure
J96.9	Respiratory faillure, unspecified
R05	Cough
R06.0	Dyspnoea (Orthopnoea, Shortness of breath)
R06.1	Stridor
R06.2	Wheezing
R06.4	Hyperventilation
R50	Fever of other and unknown origin
R50.8	Other specified fever (Fever with chills, Fever with rigors, Persistent fever)
R59.0	Localized enlarged lympf nodes
U04 S	Severe acute respiratory syndrome [SARS]
U04.9	Severe acute respiratory syndrome, unspecified

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Other test-site specific data sources

- Minimal Dataset for Emergency Physicians (MIND2)
  - Information on broad disease categories and symptoms (oxygen saturation, respiratory rate, pain, etc.)
- Individual ILI case definitions in the ED Leuven, Belgium and Santander, Spain

Notfall & Rettungsmedizin 2003 · 6:189–192
DOI 10.1007/s10049-003-0560-7

Konzepte – Qualitätsmanagement

M. Messelken[1] · Th. Schlechtriemen[2]
[1] Klinik für Anästhesiologie, Klinik am Eichert, Göppingen
[2] Klinik für Anästhesiologie, Klinikum Saarbrücken

Der minimale Notarztdatensatz MIND2

Weiterentwicklung der Datengrundlage für die Notfallmedizin

Zusammenfassung

Der minimale Notarztdatensatz MIND2 beinhaltet eine konsentierte Grundmenge von Daten (Merkmalen und Merkmalsausprägungen), die im Rahmen der prähospitalen Notfallrettung von Notarzt und Rettungsdienst dokumentiert und ausgewertet werden sollen. In dieser Publikation wird eine Synopse bisher getrennter Datensätze für Primär- und Sekundäreinsätze vorgestellt, die von den Gremien der Deutschen Interdisziplinären Vereinigung für Intensiv- und

Weiterentwicklung des Kerndatensatzes

Der minimale Notarztdatensatz MIND2 ist ein Kerndatensatz, der eine definierte und von der Deutschen Interdisziplinären Vereinigung DIVI autorisierte Menge an Mindestmerkmalen und Merkmalsbeschreibungen enthält, die zur Dokumentation in der prähospitalen Notfallrettung erforderlich sind. Er ist eine Weiterentwicklung des 1996 publizierten minimalen Notarztdatensat-

Pflichtfelder wird von jedem Rettungsmittelstandort erwartet. Aus der Menge der Wunsch- bzw. Optionsfelder kann der Anwender die für seine örtlichen Gegebenheiten sinnvollen Felder auswählen, ein externer überregionaler Datenvergleich ist durch Definition im MIND2 auch für diese Merkmale möglich.

Ziele der Dokumentation

Die rettungsdienstliche Dokumentation dient

Göppingen EP

- Case definition based on MIND2:
  - First breathing status: dyspnoea, cyanosis, spastic, rales, stridor, airway obstruction, gasping
  - OR pulse oximetry oxygen saturation <90
  - AND no injury
  - AND no circulatory disease
  - AND no psychosis/depression/mania, increased emotion

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ED Leuven

- Influenza-like illness

  Fever AND (cough OR muscle pain OR throat pain)
  OR flue (without syncope)

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ED Santander ILI

ILI case definition

1. the appearance of sudden symptoms and
2. at least one of the four general symptoms (fever or slight fever (feverishness), headache, muscle pain, general malaise)
3. and at least one of the three respiratory symptoms (Cough, sore throat, difficulty breathing)
4. and the absence of other diagnostic suspicion.

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Influenza case study

Methods

1. Pearson Correlation coefficient
2. Application early detection algorithms

Methods

(1) CDC Early Detection and Reporting System (EARS) method C1, C2, C3

[Hutwagner LC 2005, Watkins RE 2008]

(2) CUSUM with Fast Initial Response (FIR) for Poisson and normal distributed data

[Lucas JM 1982, Lucas JM 1985, Burkom H 2007]

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Early detection algorithms

- EARS (C1, C2, C3) → threshold 3 SD above baseline mean

$$C1_i = \max(0, (x_i - (\mu_{i(7-1)} + \sigma_{i(7-1)})) / \sigma_{i(7-1)})$$

$$C2_i = \max(0, (x_i - (\mu_{i(9-3)} + \sigma_{i(9-3)})) / \sigma_{i(9-3)})$$

$$C3i = \Sigma C2_i, C2_{i-1}, C2_{i-2}$$

- CUSUM with FIR

normal distributed $S_{H,t} = \max(0, z_t - 0.5 + S_{H,t-1})$

Poisson distributed $S_i = \max(0, Y_i - k + S_{(i-1)})$

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CUSUM k & h

- CUSUM – normal distributed data
  - k is set at 0.5
  - h is set at 4
- CUSUM Poisson distributed
  - Reference value k should be between the acceptable process mean (μa) and the mean level of counts (μd)
  - Decision value h is chosen by using a table look-up procedure (Lucas JM 1982)

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Influenza case study

Methods

1. Pearson Correlation coefficient
2. Application early detection algorithms
3. Sensitivity and Specificity calculations
   - Reference data weekly available
   - daily signals are aggregated to signalled weeks
     - At least one signal per week is counted
   - Sensitivity: TP/TP+FN
   - Specificity: TN/FP+TN
4. Timeliness
   - Number of days from the beginning of each outbreak identified in the reference data until the first signal for each outbreak.

Reference data

- Reference data weekly available – EMS data daily
  - Tyrol: Sick leave data acute respiratory illness of the TGKK (major insurance company, 80% of population) in Tyrol
  - Göppingen: notified influenza A cases (seasonal and H1N1 influenza) in the district Göppingen
  - Leuven: communicated epidemic periods of seasonal influenza and H1N1 2009 (weekly numbers not available)
  - Santander: ILI cases of the sentinel doctors in the Autonomous Region Cantabria

- Estimated time lag between case occurrence and analysis: 1-2 weeks

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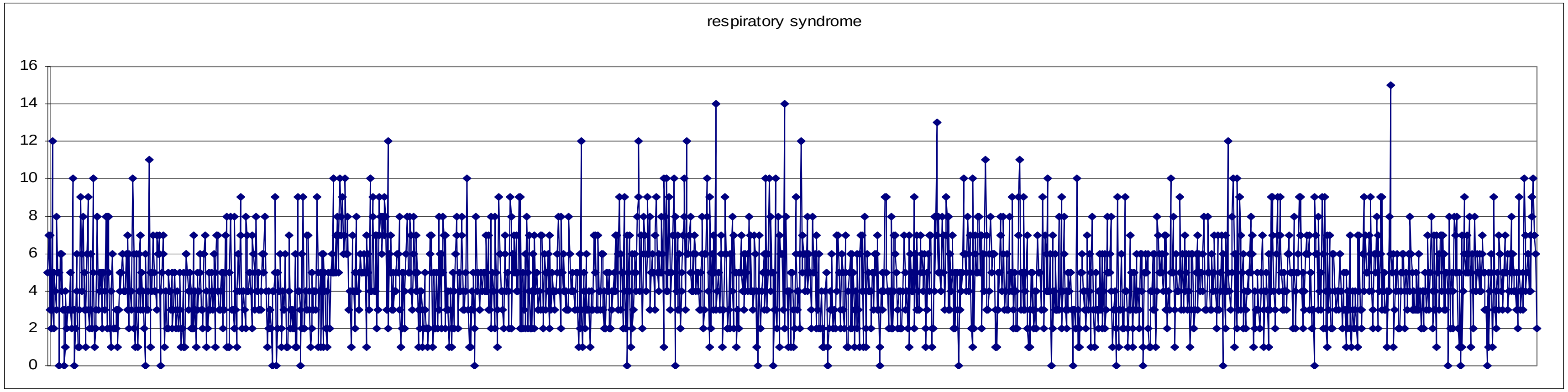
Tyrol EMD 2004-2008 (AMPDS)



	respiratory syndrome 2004-2008
Mean	4,54
Standard Error	0,05
Median	4
Mode	4
Standard Deviation	2,25
Sample Variance	5,08
Kurtosis	0,44
Skewness	0,55
Range	15
Minimum	0
Maximum	15

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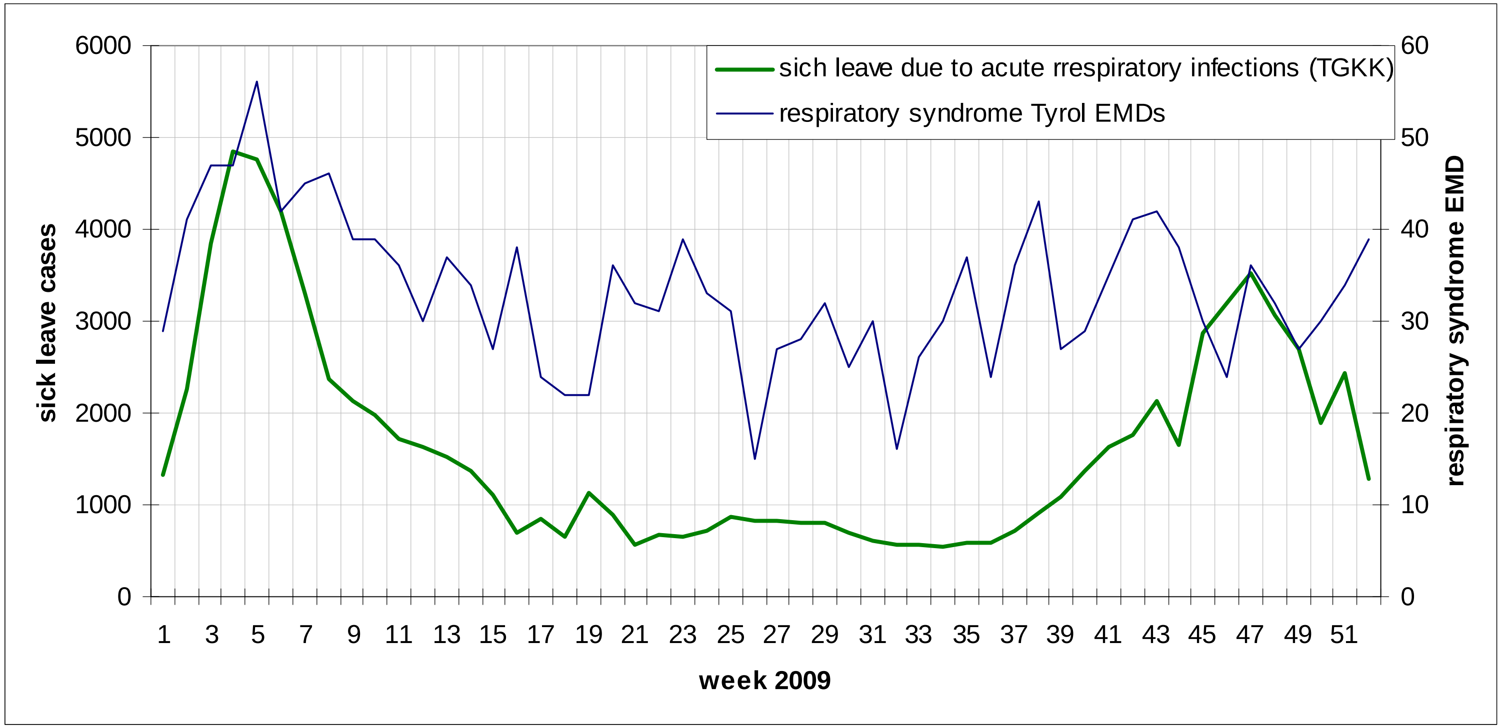
Results EMD - Tyrol



r=0.58; p<0.001

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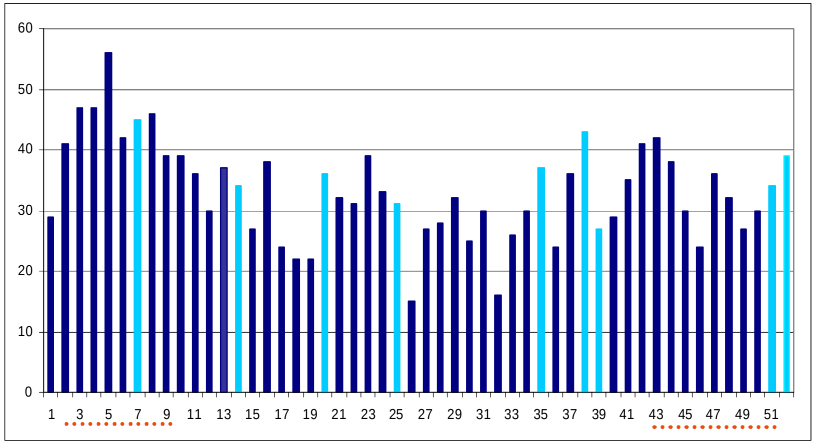
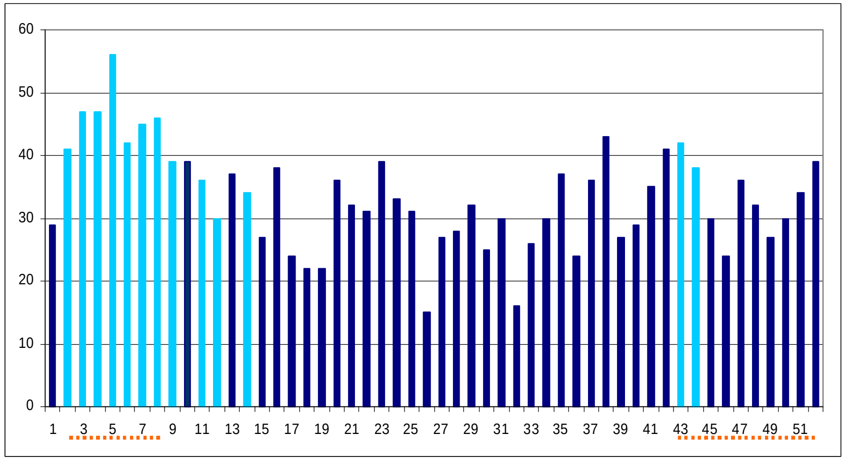
Results EMD – Tyrol (stratified)

Day-of-the-week variation (2005-2008): Sunday↑(1), Wednesday↓(3), others - (2)



EARS (C1, C2, C3) stratified



Poisson CUSUM with FIR stratified (baseline 2005-2008)

Sunday: k=6, h=10, S_0=5

Others: k=5, h=10, S_0=5

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Overview EMD (AT)

- Correlation: moderate
- CUSUM preferable
- No confirmed epidemic periods in the reference data (estimated periods)
- Sensitivity/Specificity: n.a.
- Timelines estimation (presumed beginning of epidemics in Tyrol sick leave data)
  - Period week 2-9:
    - CUSUM: Monday week 2 (day 1)
  - Period week 43-51:
    - CUSUM: Thursday week 43 (day 4)
- → reporting delay 7-14 days!

			stratified			
week	date	N	C1	C2	C3	CUSUM (strat)
2	5-Jan	8				X
	11-Jan	10				X
3	13-Jan	8				X
4	19-Jan	10				X
	22-Jan	8				X
5	26-Jan	7				X
	28-Jan	11				X
	29-Jan	11				X
6	2-Feb	9				X
	7-Feb	7				X
7	11-Feb	9			X	
	12-Feb	6				X
	13-Feb	10				X
8	21-Feb	9				X
9	28-Feb	7				X
11	10-Mar	8				X
12	18-Mar	8				X
14	30-Mar	7			X	
	1-Apr	9				X
20	12-May	11		X	X	
25	17-Jun	8		X	X	
35	24-Aug	9	X	X	X	
38	20-Sep	8			X	
39	23-Sep	6			X	
43	22-Oct	7				X
44	27-Oct	7				X
51	18-Dec	12	X			
52	21-Dec	8		X	X	
	23-Dec	8			X	

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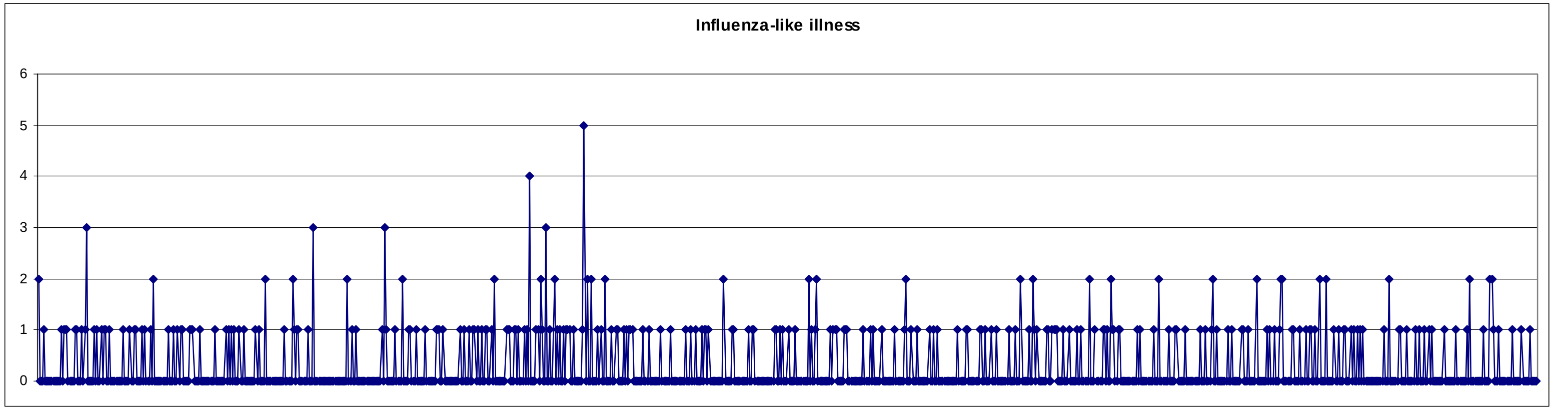
Tyrol EP 2006-2008 (ICD-10)



	ILI 2006-2008
Mean	0,28
Standard Error	0,02
Median	0
Mode	0
Standard Deviation	0,56
Sample Variance	0,31
Kurtosis	8,85
Skewness	2,43
Range	5
Minimum	0
Maximum	5

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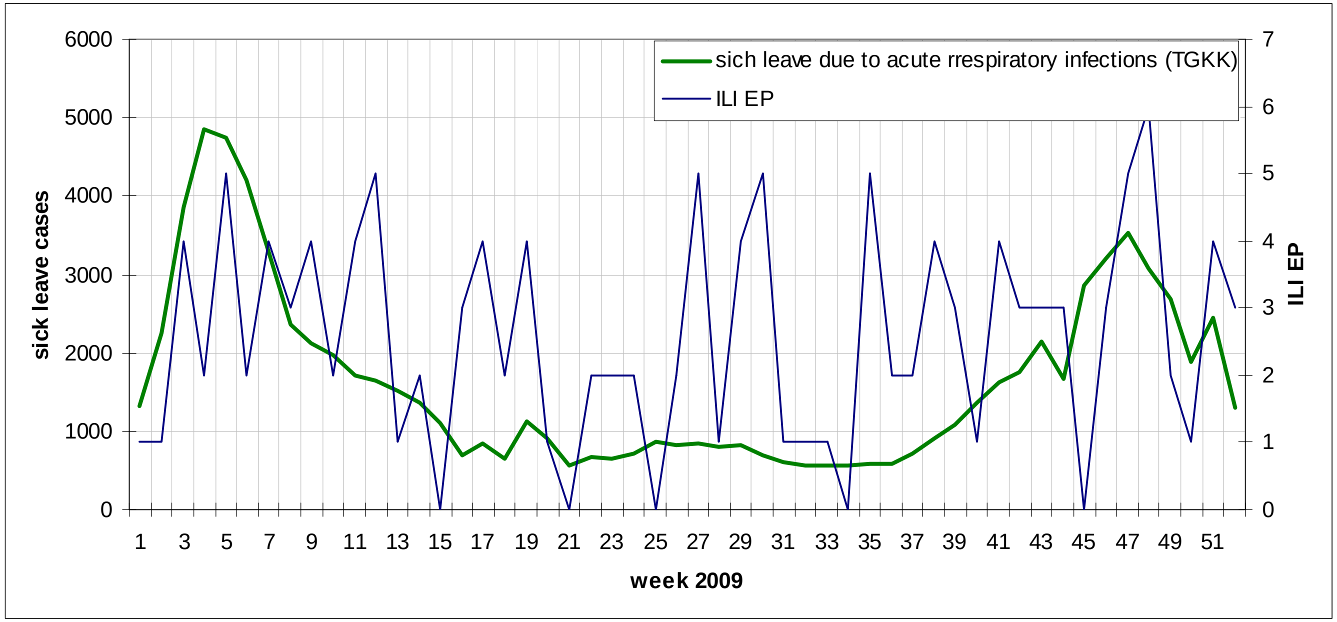
Results EP Tyrol



r=0.29 $p<0.05$

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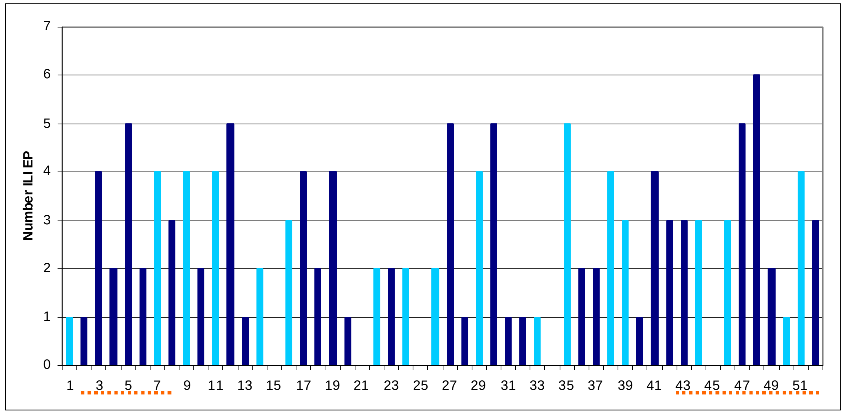
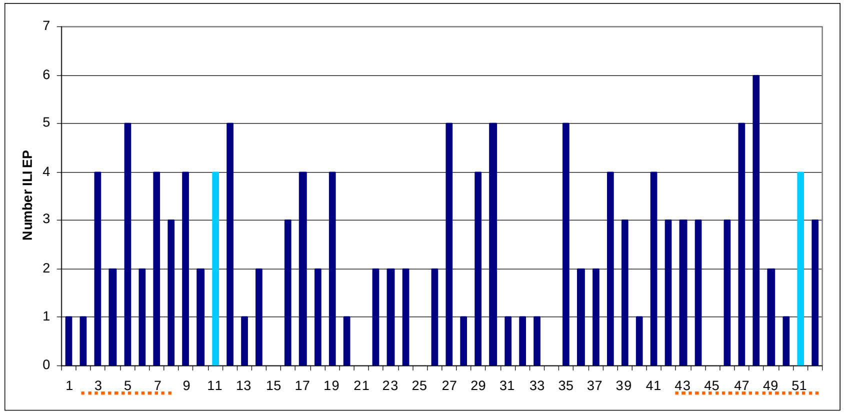
Results EP Tyrol

No day-of-the-week effect



EARS (C1, C2, C3) unstratified



Poisson CUSUM with FIR (baseline 2006-2008)

$k=0.87$, $h=2$, $S_0=1$

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Overview Tyrol EP slide

- Correlation: low
- CUSUM preferable
- No confirmed epidemic periods in the reference data (estimated periods)
- Sensitivity/Specificity: n.a.
- Timelines estimation (presumed beginning of epidemics in Tyrol sick leave data)
  - Period week 2-9:
    - CUSUM: not identified
  - Period week 43-51:
    - CUSUM: Thursday week 51 (day 60)
  - → reporting delay 7-14 days!

			ILI			ILI
week	date	N ILI	C1	C2	C3	CUSUM
1	3-jan	1	X			
7	13-feb	2	X			
	15-feb	1			X	
9	1-mrt	2		X	X	
11	9-mrt	3	X			X
14	2-apr	1	X			
	4-apr	1		X	X	
16	14-apr	1	X	X	X	
	15-apr	1		X	X	
22	27-mei	1	X	X	X	
24	13-jun	2	X	X	X	
26	25-jun	1	X	X	X	
	27-jun	1		X	X	
29	16-jul	2	X	X	X	
33	12-aug	1	X			
35	24-aug	1	X	X	X	
	26-aug	1		X	X	
	28-aug	2		X	X	
37	10-sep	1	X			
	11-sep	1		X	X	
39	25-sep	2	X			
44	29-okt	2	X			
46	11-nov	2	X	X	X	
	13-nov	1		X	X	
50	13-dec	1	X			
51	17-dec	3	X	X	X	X

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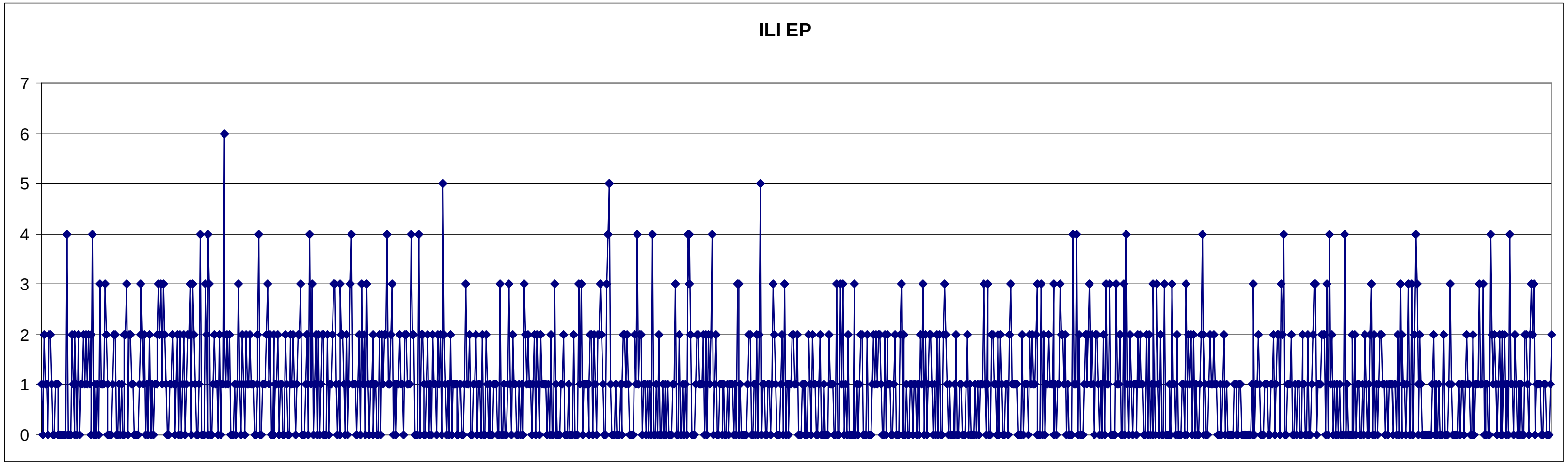
Göppingen EP 7/2005-2008



	ILI
Mean	0,97
Standard Error	0,03
Median	1
Mode	0
Standard Deviation	1,03
Sample Variance	1,06
Kurtosis	0,89
Skewness	1,04
Range	6
Minimum	0
Maximum	6

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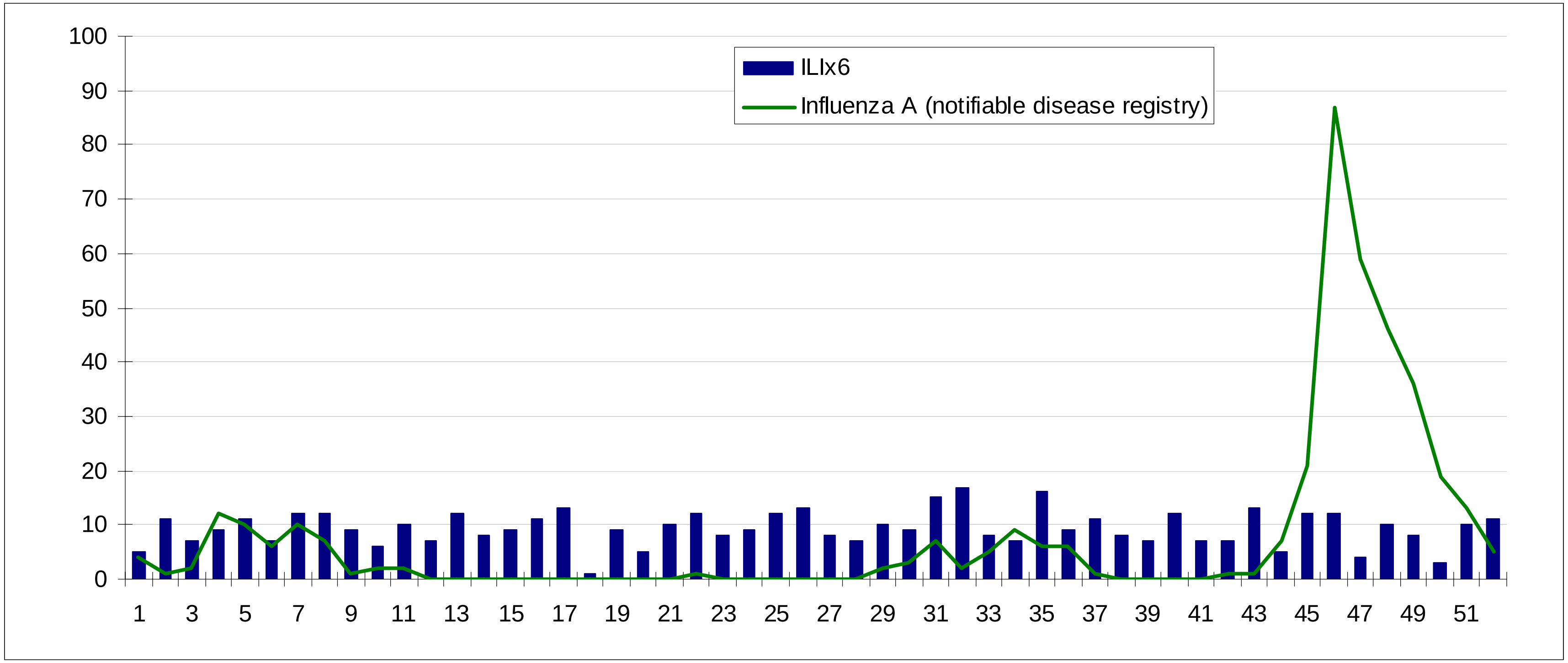
Results EP 2009



r=-0.03 p>0.05

Reference data: Cases with Influenza A in Baden-Württemberg, District Göppingen (Robert Koch-Institute: SurvStat, http://www3.rki.de/SurvStat, data status: 3-11-2010.)

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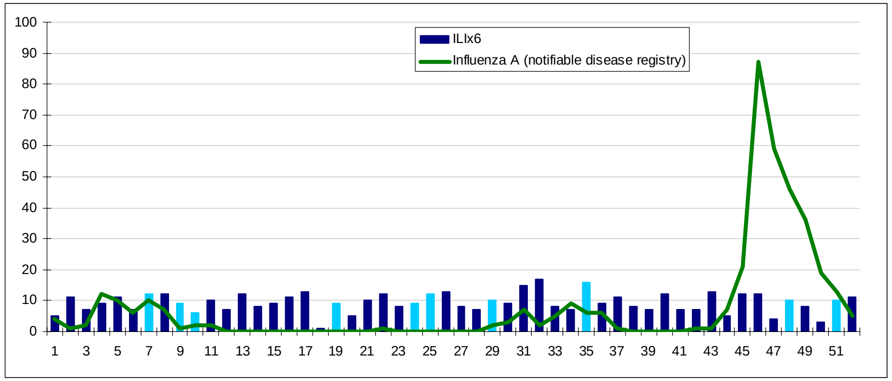
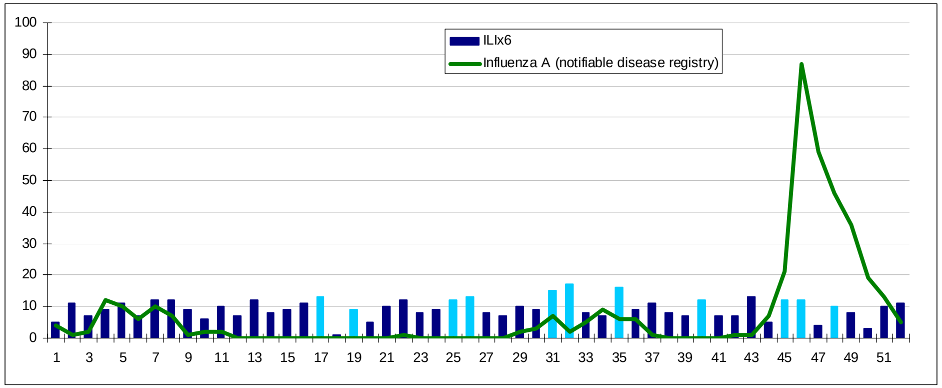
Results Göppingen EP 2009





EARS (C1, C2, C3)

Poisson CUSUM with FIR (baseline 2006-2008)

$k=0.97$, $h=3$, $S_0=2$

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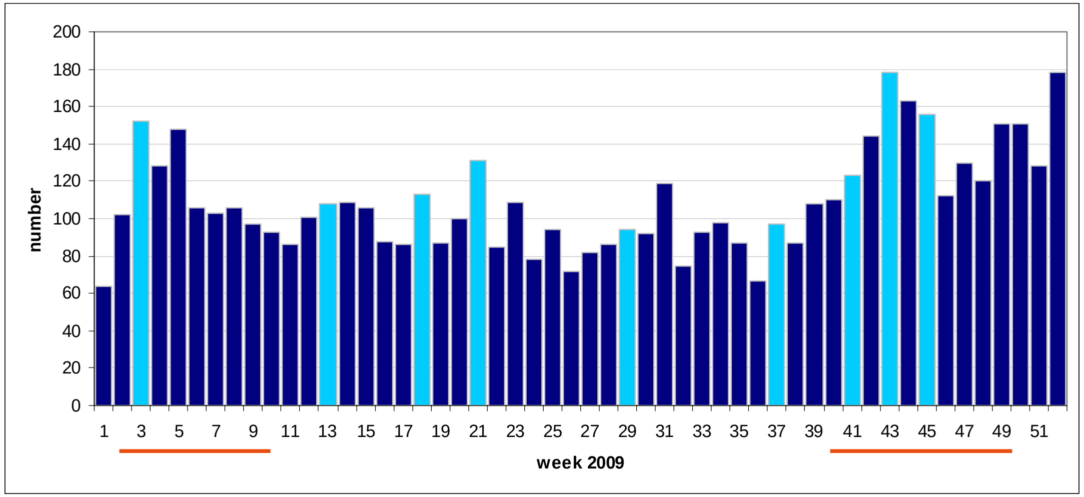
Overview Göppingen EP signals

- Correlation: none
- *No confirmed epidemic periods in the reference data*
- *Sensitivity/Specificity: n.a.*
- *Timelines estimation (presumed beginning of epidemics in Tyrol sick leave data)*
  - *Period week 4-7:*
    - *C1, C2, C3: Monday week 7 (day 22)*
    - *CUSUM: not identified*
  - *Period week 45-51:*
    - *C1, C2, C3: Wednesday week 48 (day 24)*
    - *CUSUM: Friday week 45 (day 5)*
  - *reporting delay 7-14 days!*

week	date	N	C1	C2	C3	CUSUM
7	9-feb	3			X	
9	26-feb	3	X			
10	8-mrt	3	X	X	X	
17	22-apr	4				X
19	6-mei	5	X	X	X	X
24	12-jun	3	X			
25	15-jun	4			X	X
26	25-jun	5				X
29	13-jul	4			X	
31	30-jul	4				X
32	5-aug	3				X
	8-aug	5				X
35	25-aug	5		X	X	X
40	2-okt	4				X
45	6-nov	4				X
46	11-nov	3				X
48	25-nov	4	X	X	X	
	26-nov	3				X
51	15-dec	3	X			
	16-dec	2			X	
	17-dec	2			X	
	18-dec	1			X	

Results ED Leuven

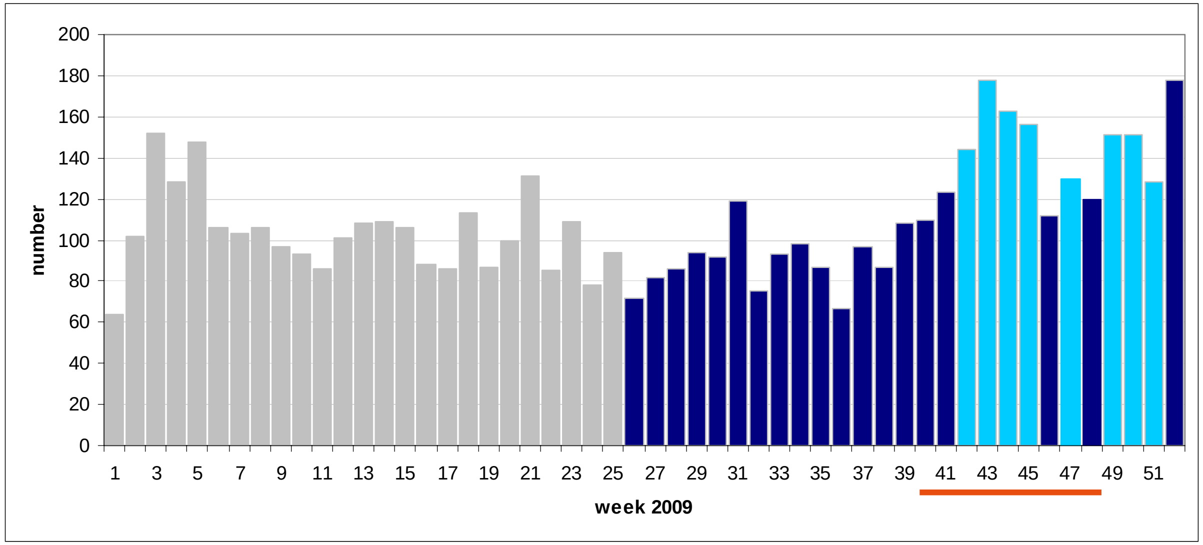
Day-of-the-week variation: Sunday and Monday↑(1), others - (2)



EARS (C1, C2, C3) stratified

Orange line: weeks with official increase of seasonal influenza (A/H3N2, week 2-10) and A/H1N1v (week 40-49) in 2009

Results Leuven



CUSUM stratified

CUSUM/FIR: Baseline 1-Jan – 30-Jun 2009

Strata Sunday/Monday: mean=17.19; SD=5.89

Strata Tuesday-Saturday: mean=14.39; SD=4.30

k=0.5; h=4;S0=2; when St-1 >= 4 →2

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Leuven - Comparison of analysis methods

EARS

Count

		ref		
		yes	no	Total
EARSstrat_sig	yes	4	5	9
	no	15	28	43
Total		19	33	52

CUSUM

Count

		ref		
		yes	no	Total
CUSUM_sig	yes	6	2	8
	no	4	14	18
Total		10	16	26

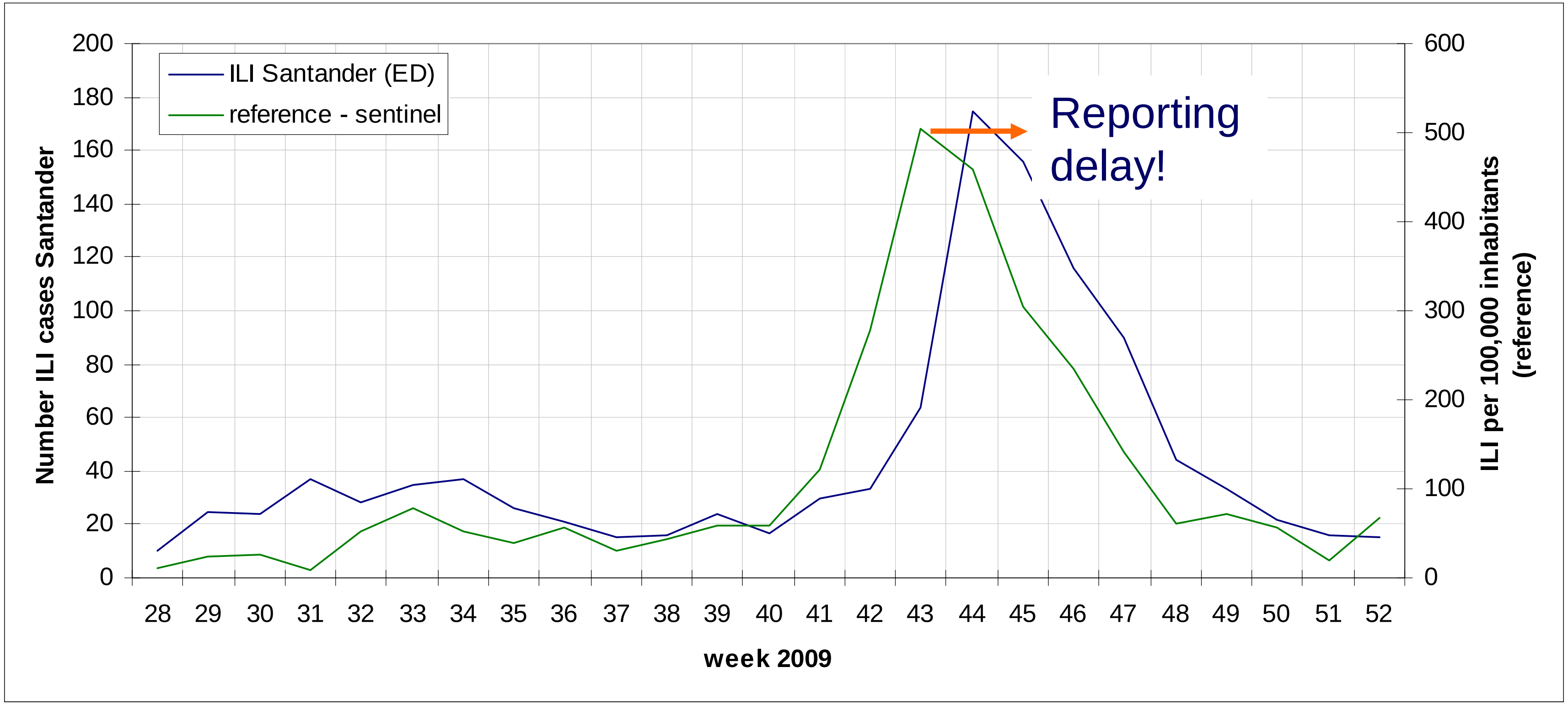
	EARS	CUSUM
Sensitivity	21,1	60
Specificity	84,8	87,5

Leuven signal overview

- Correlation: n.a.
- CUSUM preferable
- Sensitivity: 60%
- Specificity: 87%
- Timelines estimation
  - Period week 2-10:
    - EARS: Friday week 3 (day 12)
    - CUSUM: n.a.
  - Period week 40-49:
    - EARS: Wednesday week 41 (day 10)
    - CUSUM: Friday week 42 (day 19)
  - reporting delay 7-14 days!

			stratified			
week	date	N	C1	C2	C3	CUSUM (strat)
3	16-jan	32	X	X	X	
	18-jan	26				
5	28-jan	22				
	30-jan	19				
	31-jan	28				
	1-feb	26				
12	22-mrt	27				
13	25-mrt	22	X	X	X	
	27-mrt	20		X	X	
18	30-apr	24		X	X	
21	18-mei	20			X	
	19-jun	16				
29	17-jul	17			X	
31	2-aug	23				
37	10-sep	18			X	
	11-sep	11			X	
	12-sep	13			X	
41	7-okt	17	X			
	10-okt	28	X	X	X	
42	16-okt	22				X
	18-okt	28				
43	19-okt	31				
	20-okt	23				X
	21-okt	21				
	22-okt	21				X
	23-okt	26				X
	25-okt	34				X
44	27-okt	21				X
	29-okt	23				X
	31-okt	21				X
45	2-nov	24				X
	4-nov	24				
	6-nov	31	X	X	X	
47	19-nov	22				X
48	23-nov	28				
49	2-dec	25				
	3-dec	22				X
	5-dec	24				
50	7-dec	22				X
	9-dec	29				X
	10-dec	26				X
	11-dec	20				
	12-dec	23				X
51	18-dec	23				X

Weekly reference data – ILI Santander (ED)



r=0.75; $p<0.001$

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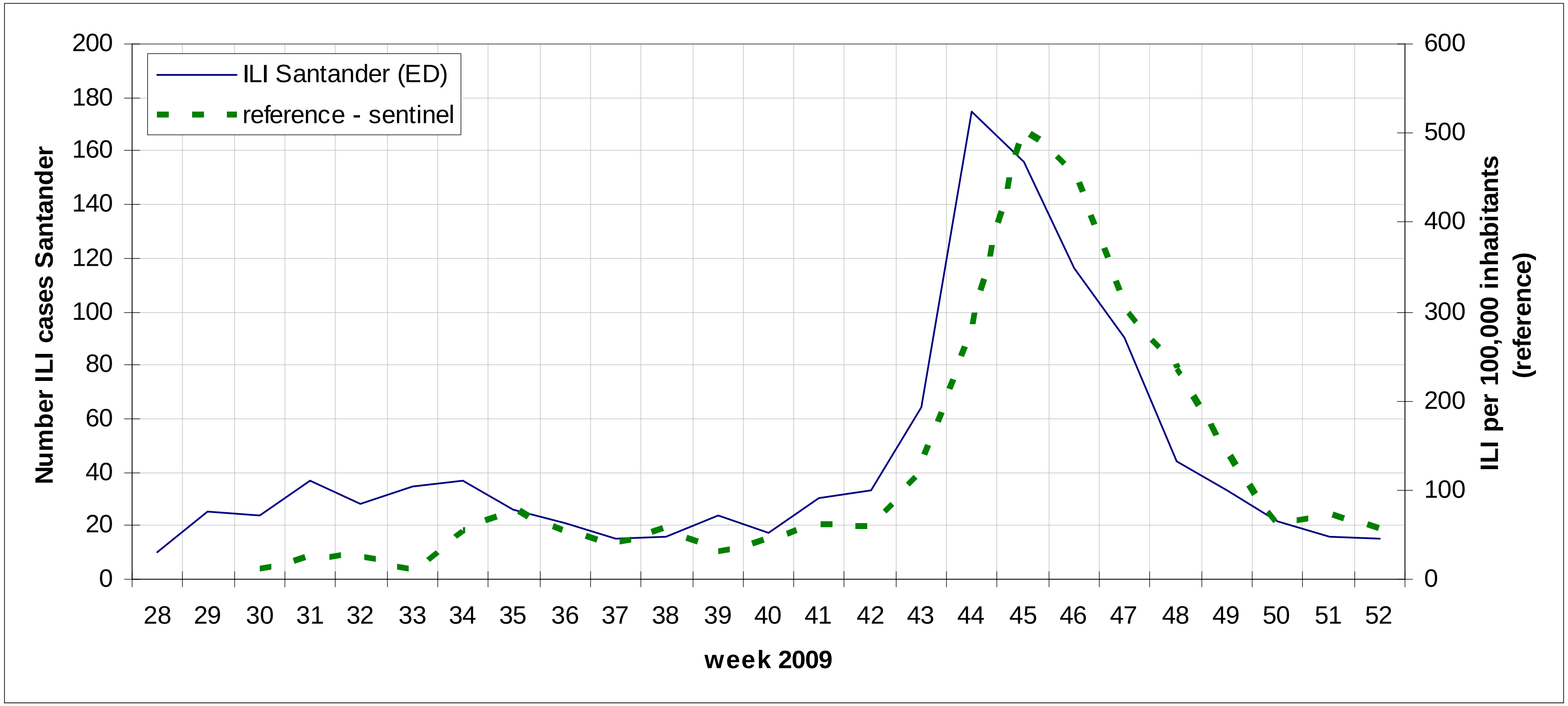
Availability of weekly reference data – ILI Santander (ED)



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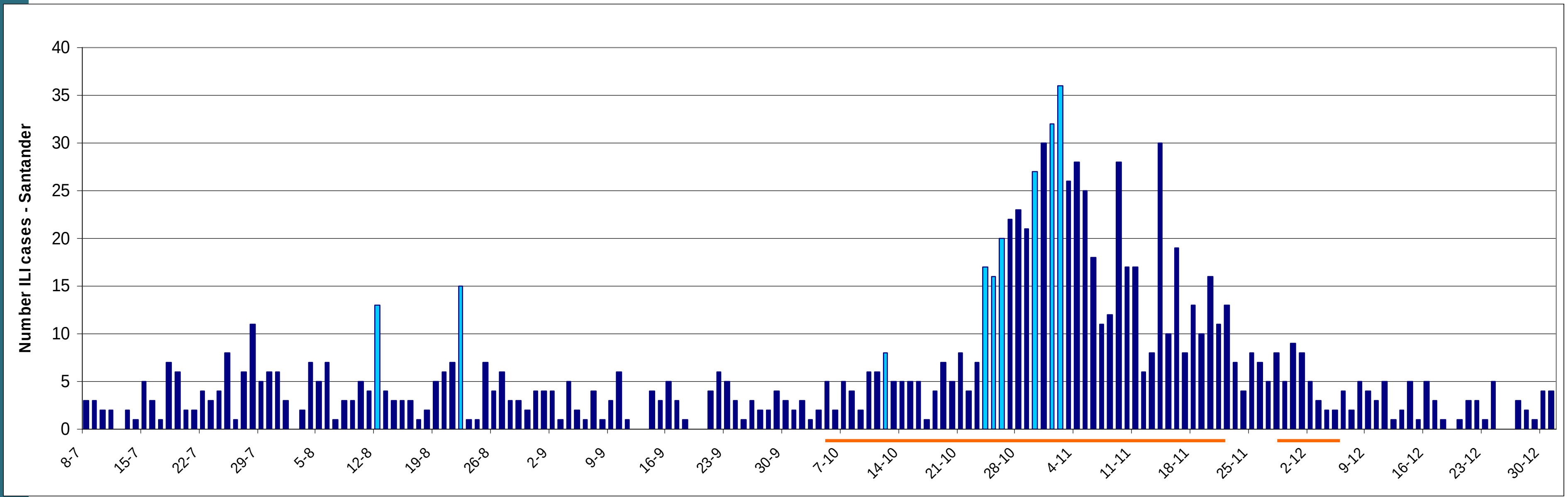
Results ED Santander

No day of the week variation



EARS (C1,C2, C3) signals on daily ILI cases

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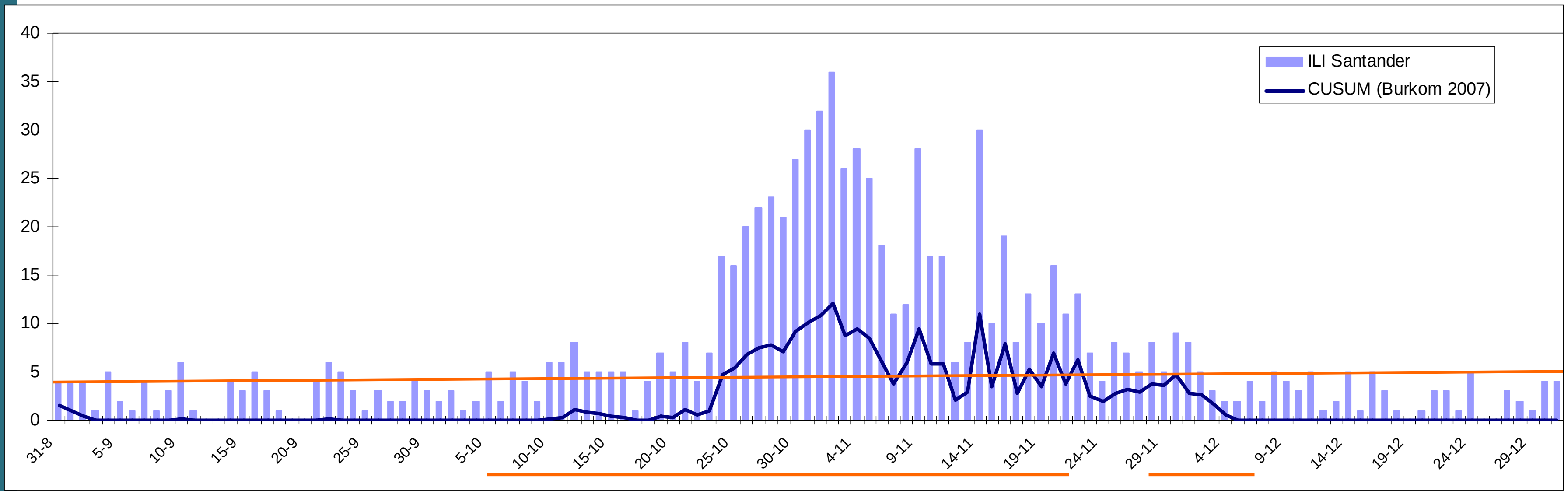
Results ED Santander



CUSUM with FIR (ILI cases week 36-52 2009)

(baseline week 28-35 2009, k=0.5, h=4, S0=2, St-1>4 --> St-1=2)

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Santander - Comparison of analysis methods

At least one EARS signal * reference data exceeds the threshold Crosstabulation

Count

		reference data exceeds the threshold		
		yes	no	Total
At least one EARS signal	yes	4	2	6
	no	4	42	46
Total		8	44	52

At least one CUSUM signal * reference data exceeds the threshold Crosstabulation

Count

		reference data exceeds the threshold		
		yes	no	Total
At least one CUSUM signal	yes	6	0	6
	no	2	9	11
Total		8	9	17

	EARS	CUSUM
Sensitivity	50	75
Specificity	95.5	100

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Signal overview Santander

- Correlation: medium-high
- Sensitivity: EARS=50%; CUSUM=75%
- Specificity: EARS=95.5%; CUSUM=100%
- Timelines estimation
  - Period week 41-47:
    - EARS: Monday week 42 (day 8)
    - CUSUM: Saturday week 43 (day 20)
  - Period week 49
    - EARS: not identified
    - CUSUM: Monday week 49 (day 1)
  - reporting delay 7-14 days!

week	date	N	C1	C2	C3	CUSUM from week 36
33	12-aug	13	X			
34	22-aug	15	X	X	X	
42	12-okt	8			X	
43	24-okt	17	X	X	X	X
	25-okt	16		X	X	X
44	26-okt	20		X	X	X
	27-okt	22				X
	28-okt	23				X
	29-okt	21				X
	30-okt	27			X	X
	1-nov	32			X	X
45	2-nov	36		X	X	X
	3-nov	26				X
	4-nov	28				X
	5-nov	25				X
	6-nov	18				X
	8-nov	12				X
46	9-nov	28				X
	10-nov	17				X
	11-nov	17				X
	14-nov	30				X
47	16-nov	19				X
	18-nov	13				X
	20-nov	16				X
	22-nov	13				X
49	30-nov	9				X

Limitations:

- Different quality of reference data
- Reference data weekly available vs. EMS data daily available
- In ED-BE and ED-ES CUSUM was calculated for shorter periods due to data needs for baseline calculation.
- EARS (C1, C2, C3) shows rather beginning of increases and gives no signal when case numbers are high over a longer time period (due to moving average baseline)→ high number of false negatives

Summary

- Influenza patterns 2009 could be identified in EMD (AT) data and ED (BE), ED (ES).
- EP data showed for this epidemic in the analysed test sites a unclear picture → assumption: severity of influenza was to low for EP involvement
- EMD (AT) and ED (ES) show medium – medium/high correlation with weekly reference data
- CUSUM is the preferred method in EMD (AT), ED (BE), ED (ES)
- High specificity → few false positive alerts (ED (BE) and ED (ES)), same indication in EMD (AT) based on Poisson CUSUM)
- Medium sensitivity
- Timeliness: taken the reporting delay into account syndromic surveillance is timelier in EMD (AT), ED (ES), and timelier to as timely in ED (BE).

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Other application possibilities of syndromic surveillance

The Icelandic ash cloud and other erupting health threats: what role for syndromic surveillance?

Helmut Brand[1], Thomas Krafft[2]*

1 Department of International Health, Faculty of Health, Medicine and Life Sciences, Research School Primary Care and Public Health (CAPHRI), Maastricht University, The Netherlands
2 SIDARTHa Scientific/Technical Coordination Office, c/o GEOMED Research Foroschungsgesellschaft mbH, Bad Honnef, Germany

Correspondence: Helmut Brand, Department of International Health, FHML/CAPHRI, Maastricht University, Universiteitssingel 40, 6229 ER Maastricht, The Netherlands, tel: +31 43 38 84006, fax: +31 43 38 84172, e-mail: helmut.brand@inthealth.unimaas.nl

While the severe impacts of the recent eruption of Iceland's Eyjafjallajökull on transportation and economy became quite obvious even in an early stage, the consequences for the public's health remained rather cloudy throughout. Contradictory messages to the public resulted from the lack of experience and even more so from the lack of reliable and recent data to assess the situation: On April 15th, the UK Health Protection Agency announced, according to BBC

structures, the system has shown its pote detection time. In the week after the firs group undertook a rapid assessment of any d health impact at the regional level in the St Austria, the County of Goeppingen in Germany, and the Autonomous Region o Spain.[2] The rapid assessment identified one the expected emergency medical services dem

Easy adaptable EMS based syndromic surveillance systems to assure that nothing happened.

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European Emergency Data-based Syndromic Surveillance System

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Thank you!

Questions?