# Clinical decision support in practice – HL7 standards, interoperablity, and selected applications

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## **Digitalization of clinical medicine**

- > Stage I: Digitizing patient medical data
  - EHRs, EMRs, Health Apps, ...
- Stage II: Digitizing clinical workflows
  - In-patient, out-patient, home
- Stage III: Digitizing medical knowledge
  - Big data vs. knowledge design





However, we're not even counting this - medical error is not recorded on US death certificates © 2016 BMJ Publishing group Ltd.

#### Data source:

http://www.cdc.gov/nchs/data/ nvsr/nvsr64/nvsr64 02.pdf



## Model for reducing patient harm



From: BMJ 2016;353:i2139





## Clinical decision support with knowledge engines













### IBM Watson Health vs. Medexter Health knowledge



### How it works



### The knowledge engine

In the future, any clinical activity will be either supported with or substituted by clinical knowledge engines.

### The knowledge

- clinically proven knowledge: rules, tables, decision trees, guidelines, scores, algorithms, ...
- > application-ready, evidence-based knowledge packages
- customized knowledge design or knowledge through machine learning

### The engine

- HL7's Arden Syntax clinical knowledge representation and processing, with fuzzy methodologies
- scalable from cloud-based servers to smartphone apps





### **Use Case: Hypoglycemia**

DATA: LET glucose BE READ {...glucose...}; **LET** physician DECT **BE DESTINATION** {sms:26789}; LOGIC: IF LATEST glucose IS LESS THAN 50 THEN CONCLUDE true; **CONCLUDE TRUE** ENDIF;  $\rightarrow$  Do something **ACTION:** WRITE "Warning…" AT physician DECT;

by Stefan Kraus



### Hypoglycemia alert via DECT cordless telecommunications



Event monitors are

"tireless observers, constantly monitoring clinical events"

George Hripcsak

by Stefan Kraus





## One of the rules to interpret clinically relevant findings (rule premises form equivalent classes)

### RULE 103:

### IF one of the following 100 combinations

HBsA	HBsAg anti-HBs		anti-HBc	IgM anti-HBc	HBeAg	anti-HBe		
+	•	+	— ±	- ± •	+	- ± •		
+	•	+	+ •	+ - ± ●	+	+ - ± •		

### THEN

The simultaneous occurrence of HBe-antigen and anti-HBs antibodies is a rare event in the natural course of a hepatitis B virus infection. This constellation of findings may be attributed to one of the following causes: (a) circulating HBsAg-anti-HBs immune complexes, (b) hepatitis B virus infection coinciding with a hepatitis B vaccination or injection of HB-hyperimmune globulin, or (c) reinfection with a hepatitis virus B with a different HBsAg subtype. Blood and secretions (saliva, sperm, breast milk) of such patients are to be regarded as infectious.



### hepatitis serology test results

• A1 🗢	15:31			76%						
	Hepaxpert									
Input of test results										
Hepatitis A Serology				~						
anti-HAV	positive	negative	borderline	not tested						
IgM anti-HAV	positive	negative	borderline	not tested						
HAV-RNA	positive	negative	borderline	not tested						
Hepatitis B Serology				~						
HBsAg	positive	negative	borderline	not tested						
anti-HBs	positive	negative	borderline	not tested						
anti-HBc	positive	negative	borderline	not tested						
IgM anti-HBc	positive	negative	borderline	not tested						
HBeAg	positive	negative	borderline	not tested						
anti-HBe	positive	negative	borderline	not tested						
anti-HBs titre	nti-HBs titre enter value between 0 and 99,999 in U/I U/I									
Hepatitis C Serology				~						
anti-HCV	positive	negative	borderline	not tested						
HCV-RNA	positive	negative	borderline	not tested						
	Interpretation About									



The simultaneous occurrence of HBe-antigen and anH-BBs antibodes is a rare event in the natural course of a hepatitis B vivs infection. This constraintion of findings may be attributed to one of the following causes: (a) circulating HBadg-anH-HBs immune complexes, (b) hepatitis B vivs infection cencicity with a hepatitis B vivs accleataton or injection of HB-hyperimmune globulin, or (c) enirefaction with a hepatitis Vivs that afflement HBadg-attribute, Biodd and servicins (sains, sperm, treast milk) of such patients are to be regarded as infections. In order to data no coulquie information on the ambiouson and their or coalitive easilit. It is accommended to them even material sent in for testing

In order to obtain conclusive information on the ambiguous negative or positive result, it is recommended to have new material sent in for testing and/or to consult with the head of the laboratory.



	100	
Hepaxpert Input of test results	*‴ ad 87% ∎ 13:03	* all 81% ■ 14:06
Hepatitis A Serology	~	Hepatitis A Serology
IgM anti-HAV	not tested -	HBsAg
Hepatitis B Serology	◆ negative <del>-</del>	anti-HBc IgM anti-HBc HBeAg
anti-HBs anti-HBc	not tested -	anti-HBe anti-HBs titre 120 U/I
lgM anti-HBc HBeAg	negative ◄ not tested ◄	This constellation of findings (positive anti-HBs antibodies, with negative IgM anti-HBc antibodies) indicates the presence of immunity to the hepatitis virus B. This immunity may either have been acquired naturally upon
anti-HBe anti-HBs titre	not tested - 120 U/I	restitution following a hepatitis B virus infection or it may have been induced by active or passive immunization. <u>Vaccination. Recommendation:</u> If an indication for a hepatitis B vaccination exists, the primary course of
Hepatitis C Serology anti-HCV HCV-RNA	negative -	immunization has been completed, the last partial vaccination was given at least 1 month previously, and the vaccinated person's immunity is unimpaired, then a hepatitis B vaccination (or a follow-up anti-HBs titre check) within 1 year, based on the titre examination date, is to be recommended at the measured anti-HBs titre value of 120.
Interpretation	lbout	Back New Input About

- includes frequent, rare, as well as inconsistent combinations
- complete coverage of the problem domains
- e.g., hepatitis B serology: about 150 rules in 3 layers for 61,440 possible combinations

#### Inflammation Monitoring and Alerts



### ■ Medexter Demo KIS

-

🕆 Dashboard	Mustermann, Max													
😁 Patients	Adam, Reinhard		Musterm	ann, Max	NINO	122.41	100966							
▲ Laboratory	Auer, Dietmar		Age:	48	Case Number:	46889	95							
🕄 Ambulance	Bauer, Stefanie		Date of Birth:	08-10-1966	Hospital Admit	tance: 04-15	-2015							
🖹 Forms	Berger, Anita													
Medication	Cruzcer, Karin	Documents	O Vital Sig	ns 👗 Laboratory	🖈 Diagnoses	🛉 Radiology	📓 Images	Reference:	s 🕼 Outside Reco	ords				
A Deporting	Dietrich, Dominik			04-18-2015 13:02	04-17-2015 12:52	04-16-2015	11.29 04	15-2015 13:37	Clinical Alerts					
Keporting	Falli, Robert			04 10 2010 15102		04102013	1125 04	15 2015 15157						
• Preferences	Frauenstein, Lisa	Leukocytes	CAL PROFILE	19.4 /nl	20.1 /nl	17.5 /nl	17 1	/nl	GENERATED	MESSAGES				
	Grutsch, Renate			-	-	-	-	711	04-18-2015 13:02	Further increase of CRP				+
	Heiter, Thomas								04-18-2015 13:02	Persistent leukocytosis	4 /nl. 04-18-2015 13:02) ci	ompared to previous findi	ings:	_
	Huber, Karl	BIOCHEMICA	PROFILE							04-17-2015 12:52	Leukocutes 20.1 /nl	04-17-2015 12:52	CRP 105 mg/l	
	Hufnagl, Martin	Electrolytes								04-16-2015 11:29	Leukocytes 17,5 /nl	04-16-2015 11:29	CRP 98 mg/l	
	Kaindl, Laura	Potassium		-	-	-	-			04-15-2015 13:37	Leukocytes 17,1 /nl	04-15-2015 13:37	CRP 80 mg/l	
	Kaiser, Franz								04-17-2015 12:52	Further increase of leukocy	tes			+
	Kapferer, Johannes	Inflammation markers C-reactive protein							04-15-2015 13:37	7 Leukocyte value indicates leukocytosis Leukocyte value indicates leukocytosis: 17,1 /nl (04-15-2015 13:37). Consider CRP.				-
	Lander, Simon			169 mg/l	105 mg/l	98 mg/l	80 r	ng/l					RP.	
	Leitmayer, Sonja Loidl, Elisabeth								04-15-2015 13:37	Moderately increased CRP				+
			on											
	Maier, Franz	Serum creatinir	ne	-	-	-								
	Maier, Sabin	Urea		-	-	-								
	Neuwirt, Markus													
	Schneider, Stefan	Enzymes												
	Seidl, Anita	Troponin		-	-	-	-							
	Tauern, Barbara													
	*													



## To summarize

- Arden Syntax software: versatile, scalable, data- and knowledgeprocessing software for CDS and quality measures; Fuzzy Arden Syntax for linguistic and propositional uncertainty
- High integratability through web services and database connectors
- Cockpit monitoring of and dashboard analytics for adverse events
- Reporting and quality benchmarking of adverse events
- Users: patient-care institutions; healthcare, research, and teaching institutions; health IT companies; and consumers



## Challenges to clinical decision support

- mental
  - necessity or imperative not recognized (fatalistic attitude towards risk/suffering)
  - factual incomprehension (don't understand it)
  - emotional refusal (don't want it)
  - insufficient endorsement (don't do it)
- clinical
  - too simplistic or insufficient quality (lack of content quality)
  - lack in workflow integration (lack of process quality)
- technical
  - lack in structured patient data (documentation)
  - insufficient data/semantic interoperability (data and terminology standards)
- financial
  - insufficient funds (often not true!)
- $\Rightarrow$  How to overcome these barriers? By clinically useful solutions.

## **CLINICAL DECISION SUPPORT**

The Road to Broad Adoption



## Improving Outcomes with Clinical Decision Support An Implementer's Guide

**Second Edition** 

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## Himss

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MA American Medical Informatics Association

