

Use of SNOMED CT in a Clinical Decision Support System for Critical Care

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Objectives

Describe how SNOMED CT can be used to normalize clinical data from disparate systems for a clinical decision support system (CDSS).

Describe how SNOMED CT can be used for intra-system communication in a CDSS.

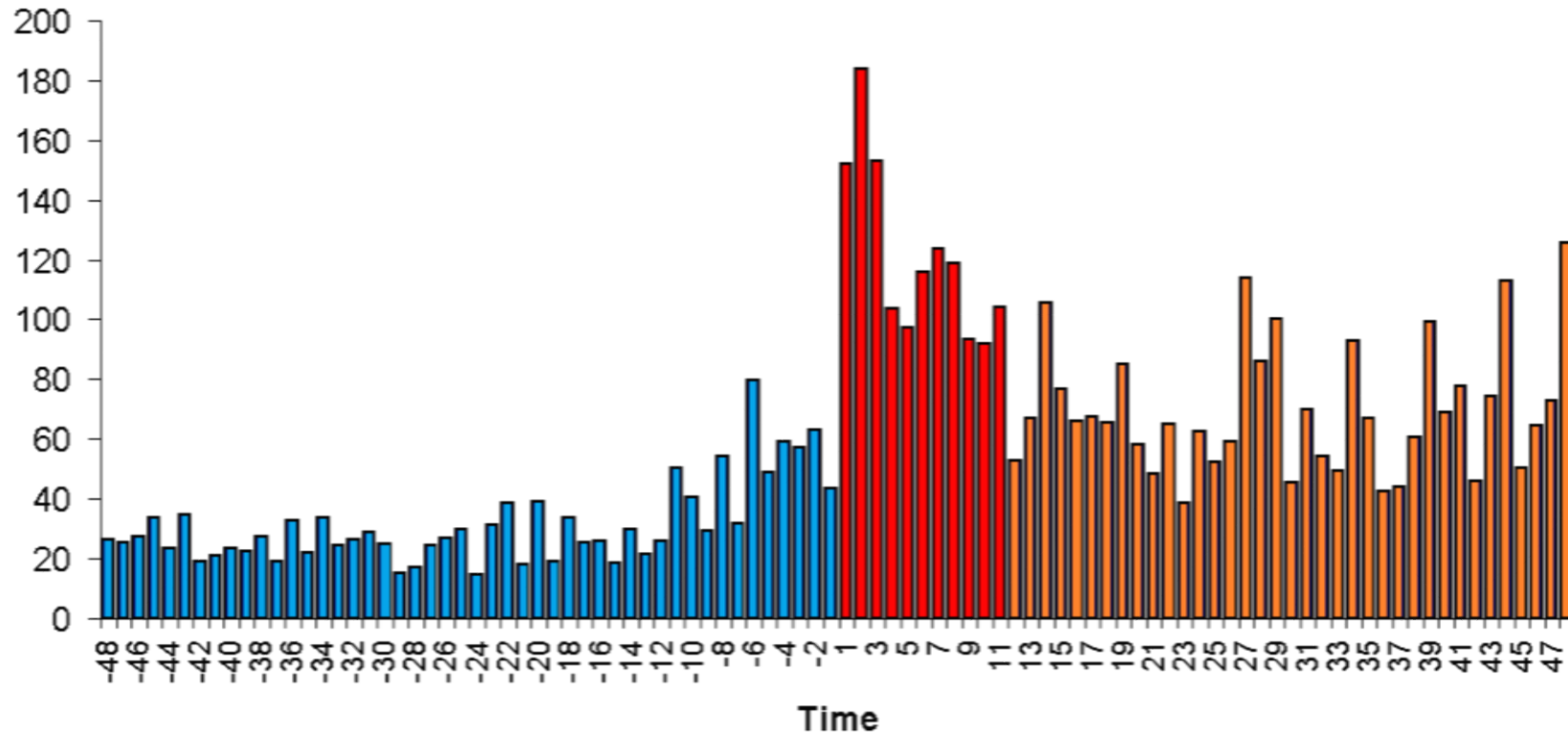
What is Clinical Decision Support?

Clinical decision support (CDS) provides clinicians, staff, patients or other individuals with **knowledge** and **person-specific information**, intelligently **filtered** or presented at appropriate times, to enhance health and health care. The Office of the National Coordinator for Health Information Technology (ONC) . Clinical Decision Support (CDS). Retrieved September 28, 2017, from URL <https://www.healthit.gov/policy-researchers-implementers/clinical-decision-support-cds>

Clinical Decision Support is a process for **enhancing** health-related decisions and actions with **pertinent, organized** clinical knowledge and patient information to improve health and healthcare delivery. Osheroff JA et al. (2012). *Improving outcomes with clinical decision support: an implementer's guide (2nd Edition)*. Chicago: Healthcare Information and Management Systems Society Press

The Challenge: Data Volume in the ICU

Total data points per patient-hour



Microbiology, labs, medications,
chest X-ray, Nurses flow sheet,
Clinical notes (history and
impression/plan) –
Vitals Signs excluded!

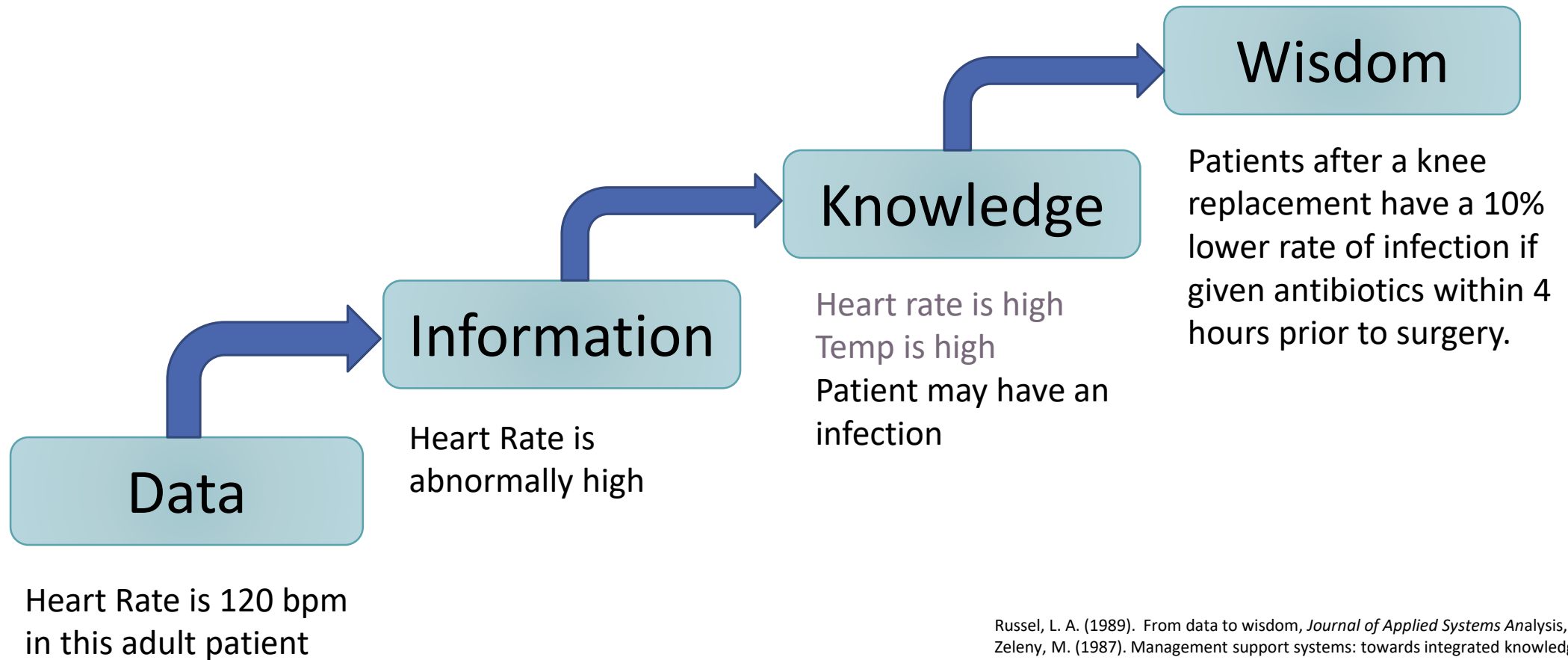
An average of **1348**
points of data are
collected each day per
patient, with the quantity
of data increasing **26%**
over **5** years. ^[1]

Day 1 represents the first day of ICU
admission

Herasevich V, Litell J, Pickering B. Electronic medical records and mHealth anytime, anywhere. *Biomed Instrum Technol.* 2012 Fall;Suppl:45-8. doi: 10.2345/0899-8205-46.s2.45. PubMed PMID: 23039776.

[1] Manor-Shulman O, Beyene J, Frndova H, Parshuram CS. Quantifying the volume of documented clinical information in critical illness. *J Crit Care* 2008; 23(2): 245-250.

DIKW Hierarchy



Russel, L. A. (1989). From data to wisdom, *Journal of Applied Systems Analysis*, 16
Zeleny, M. (1987). Management support systems: towards integrated knowledge management." *Human Systems Management*, 7

One Solution to the Challenge: A CDSS

Care Unit View

The screenshot displays a 'Care Unit View' interface. At the top, there is a navigation bar with 'General' and 'CSICU' tabs, and a search bar labeled 'Find a patient'. Below this, several patient cards are arranged in a grid. Each card shows the room number, patient name, age, and length of stay (LOS). The cards include icons for various medical conditions and procedures. A larger, detailed card for patient Linda Smith in room 22-A is shown in the foreground, featuring a purple flower icon and a row of icons representing different medical systems: brain, heart, lungs, kidney, stomach, and a magnifying glass over a cell.

17-A
Koot
Vivian
545675431 Age: 84 LOS: 1 days

18-A
Vacant

19-A
Perry
Mary
545675931 Age: 72 LOS: 1 days

20-A
Li
Jia
545676931 Age: 42 LOS: 1 days

21-A
Patorski
David
545678231 Age: 33 LOS: 1 days

22-A
Smith
Linda
545678567 Age: 76 LOS: 1 days

16-A
Michael
Paul
545674431 Age: 43 LOS: 1 days

15-A
Geary
Kevin
545679162 Age: 57 LOS: 1 days

14-A
Smith
Lynda
545679980 Age: 66 LOS: 1 days

22-A
Smith
Linda
545678567 Age: 76 LOS: 1 days

Not available in the U.S.

A CDSS system

- Critical care adults
- Purpose is to transform patient data into knowledge and information
- Design based upon usability and clinician data usage studies
- Supported by research grants from the USA government
- Focus of research at 3 hospitals
- Shows positive results
- Is now commercially available

Individual Patient View

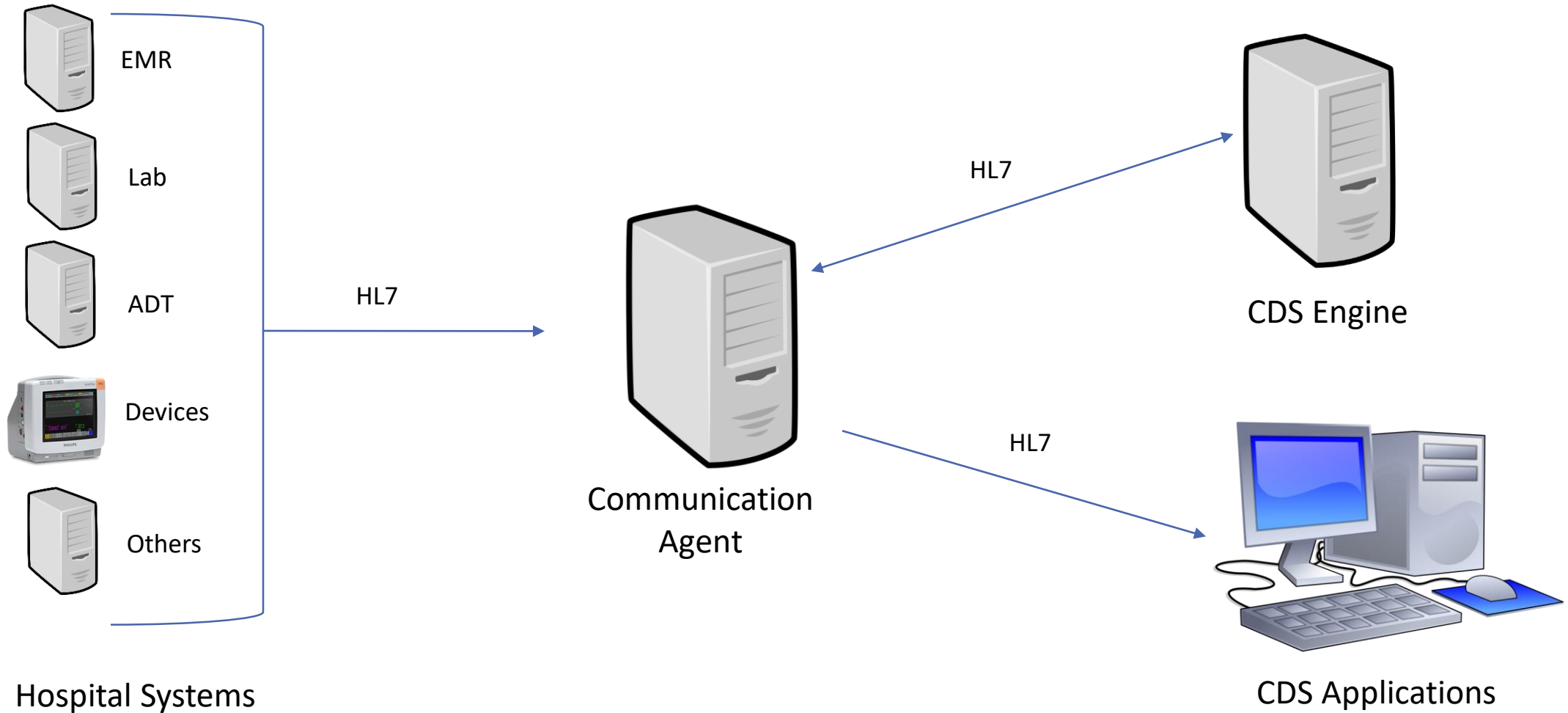
The screenshot displays a patient's medical record for Linda Smith, 8/17/1926 (76 yrs), ID 545678567. The interface is organized into several panels:

- Navigation Menu:** Located on the left side, containing sections for Notes, Procedures, and Operative Notes.
- Demographic Information:** Located at the top center, showing patient name, date of birth, and ID.
- Allergies Information:** Located at the top right, showing a list of allergies.
- Tools Menu:** Located at the top right, providing access to various clinical tools.
- Body System:** A central panel displaying vital signs and lab results, including HR (95), ABP Mean (63), NIBP Mean (65), Troponin (0.146), Lactate (4.1), SvO2 (N/A), SpO2 (92), PaO2 (76), Art pH (6.57), Art PCO2 (15), Art HCO3 (14), and Art Base Excess (<-30.0).
- Notes Panel:** Located at the bottom left, showing a procedure note from 4/3/2017 12:32 PM.

- Presents high-value relevant patient information on a single screen
- Provides more in-depth medical history and physiologic data organized by organ system and with visual cues indicating status

Not available in the U.S.

CDSS Topology



IT Systems to Communication Agent

- HL7 Messages to Communication Agent
 - ADT HL7 messages such as the A01, A08, A02, etc. to admit, transfer, discharge patient
 - ORU messages from EMR, devices, and labs for patient observations
 - MTM messages for documents and test reports
- IT systems data is identified by the sending system using the senders desired terminology such as LOINC
- Only those data elements pertinent to the CDS algorithms and to the application are captured

Role of Communication Agent in Inbound

- **Transform** inbound data into HL7 messages understood by the CDS engine
 - Transform inbound HL7 messages to ORU messages
 - Translates ADT messages as needed
- **Translates** inbound identifiers into SNOMED CT concepts
 - Maps any inbound identifiers to SNOMED CT using a mapping file for a fixed set of identifiers
 - Maps inbound drugs to key drug therapeutic category, based upon American Hospital Formulary Service (AHFS)
- **De-Identifies** patient data sent to the CDS engine
 - In preparation to place the CDS engine in the cloud – if desired by customers. Research program was cloud based
- **Exports** HL7 messages as ORU and ADT to the CDS Engine

Example of Customer Mapping

SNOMED CT	Name	UOM	Inbound Identifiers
59573005	Potassium measurement (procedure)	mmol/L	L14 (Basic Metabolic Panel), "Potassium^POTASSIUM" L10407 (Comprehensive Metabolic Panel), "Potassium^POTASSIUM" L174 (Potassium), "Potassium^POTASSIUM"
105011006	Blood urea nitrogen measurement (procedure)	mg/dL	L1190 (Urine, Urea Nitrogen), "Urine, Urea Nitrogen^UREA NITROGEN UR" L14 (Basic Metabolic Panel), "Urea Nitrogen^UREA NITROGEN" L10407 (Comprehensive Metabolic Panel), "Urea Nitrogen^UREA NITROGEN" L191 (Urea Nitrogen), "Urea Nitrogen^UREA NITROGEN" L10257 (Pre and Post Dialysis BUN with Kt/V Ratio), "Pre-Dialysis Urea Nitrogen^Pre-Dialysis BUN" L10257 (Pre and Post Dialysis BUN with Kt/V Ratio), "Post-Dialysis Urea Nitrogen^Post-Dialysis BUN"
25197003	Sodium measurement (procedure)	mmol/L	L10431 (Venous, Blood Gas, Comprehensive), "Venous, Sodium^Sodium, Venous" L10401 (Venous, Blood Gas, Electrolytes and Metabolites), "Venous, Sodium^Sodium, Venous" L14 (Basic Metabolic Panel), "Sodium^SODIUM" L10407 (Comprehensive Metabolic Panel), "Sodium^SODIUM" L181 (Sodium), "Sodium^SODIUM" L10429 (Capillary, Blood Gas, Comprehensive), "Capillary, Sodium^Cap Sodium" L10291 (Capillary, Blood Gas, Electrolytes and Metabolites), "Capillary, Sodium^Cap Sodium" L10427 (Arterial, Blood Gas, Comprehensive), "Arterial, Sodium^SODIUM-BLOOD GAS" L128 (Arterial, Blood Gas, Electrolytes and Metabolites), "Arterial, Sodium^SODIUM-BLOOD GAS"

Contents of file is used to configure the mapping in the communication agent

ORU message from Agent to CDS Engine

MSH|^~\&|||||20150726000524||

ORU^R01|HP0726000525998-7-842|P|2.3|||||8859/1|||Monitor

PID|||B3B604A7AD4E4A2E8D7EF321FE4B7B44^^^MR||284CD224E2FA4475AC93395BDB28E665

PV1|||1^9^9^1

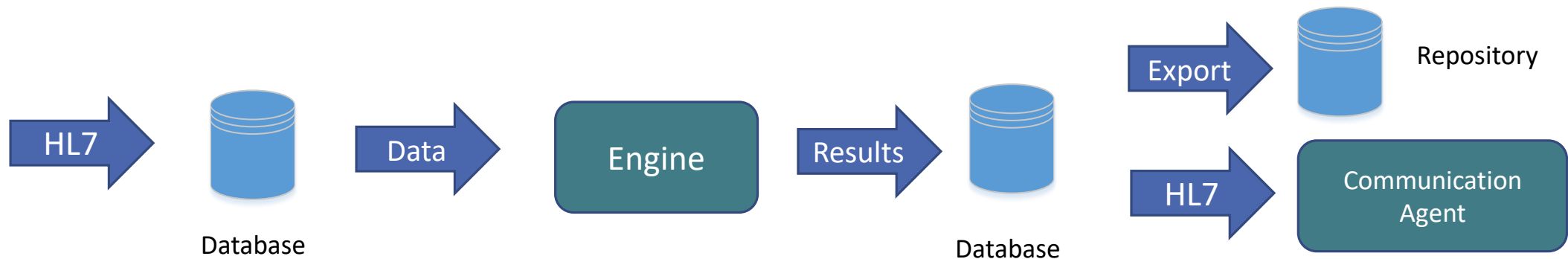
OBR|2|||364075005^Heart rate (observable entity)^SNM|||20150726000524

OBX|1|NM|364075005^Heart rate (observable entity)^SNM|0|107|||||F

OBX|3|ST|118170007^Source^SNM||Monitor

CDS Engine

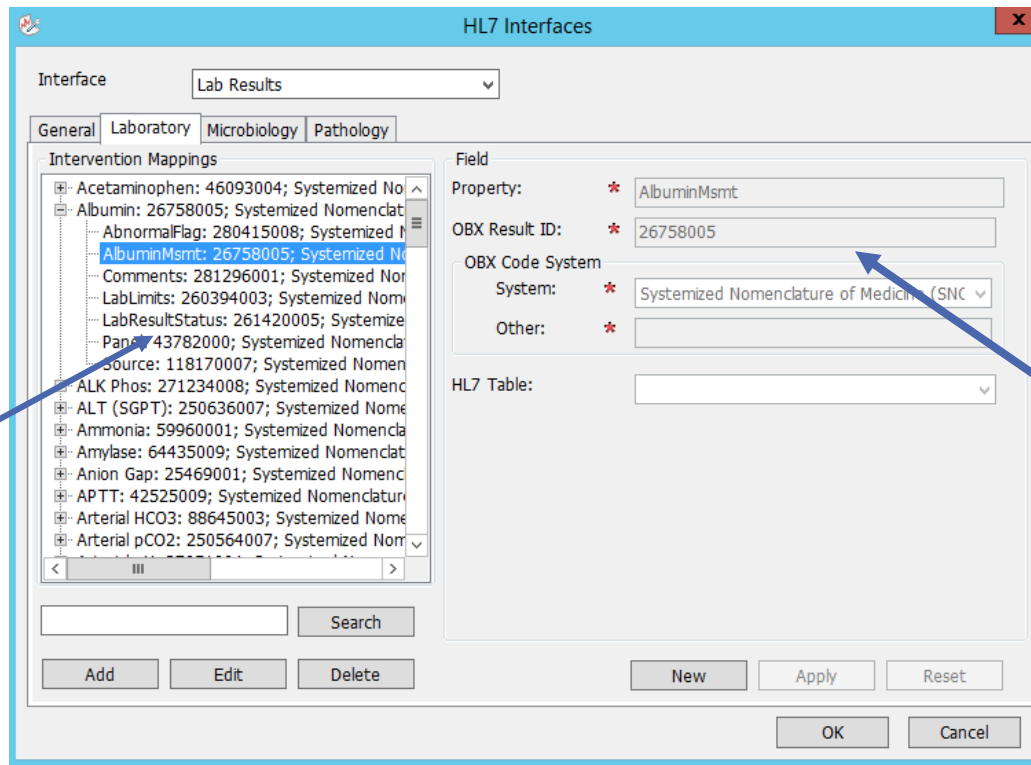
- Accepts the inbound patient data and stores it into the database.
- Inbound data is mapped to CDS engine data dictionary using SNOMED CT.
- Executes clinical algorithms on that data and generates results, stored in the database
- Results data dictionary items are tagged with SNOMED CT
- Results are exported via HL7 as ORU messages with SNOMED CT
- Inbound data and results are copied into in a data repository with SNOMED CT



CDS Algorithms

- A fixed set of algorithms as defined by the research program
- Algorithms do the following in general
 - Assigns parameter to body system
 - Identifies whether the data is normal, abnormal, or critical based upon clinical algorithms
 - Identifies whether the data is current, old, very old, or obsolete
 - Totals fluids intakes
 - Identifies the statuses of a body systems as normal, abnormal, or critical
 - Identifies whether the patient is on key therapies like vasopressor drugs or respiratory ventilation
- Algorithm Source
 - Algorithms are based upon clinical research for adult critical care patients in multiple US hospitals
 - Identify issues important to survival and recovery

Mapping SNOMED CT Inbound in Engine

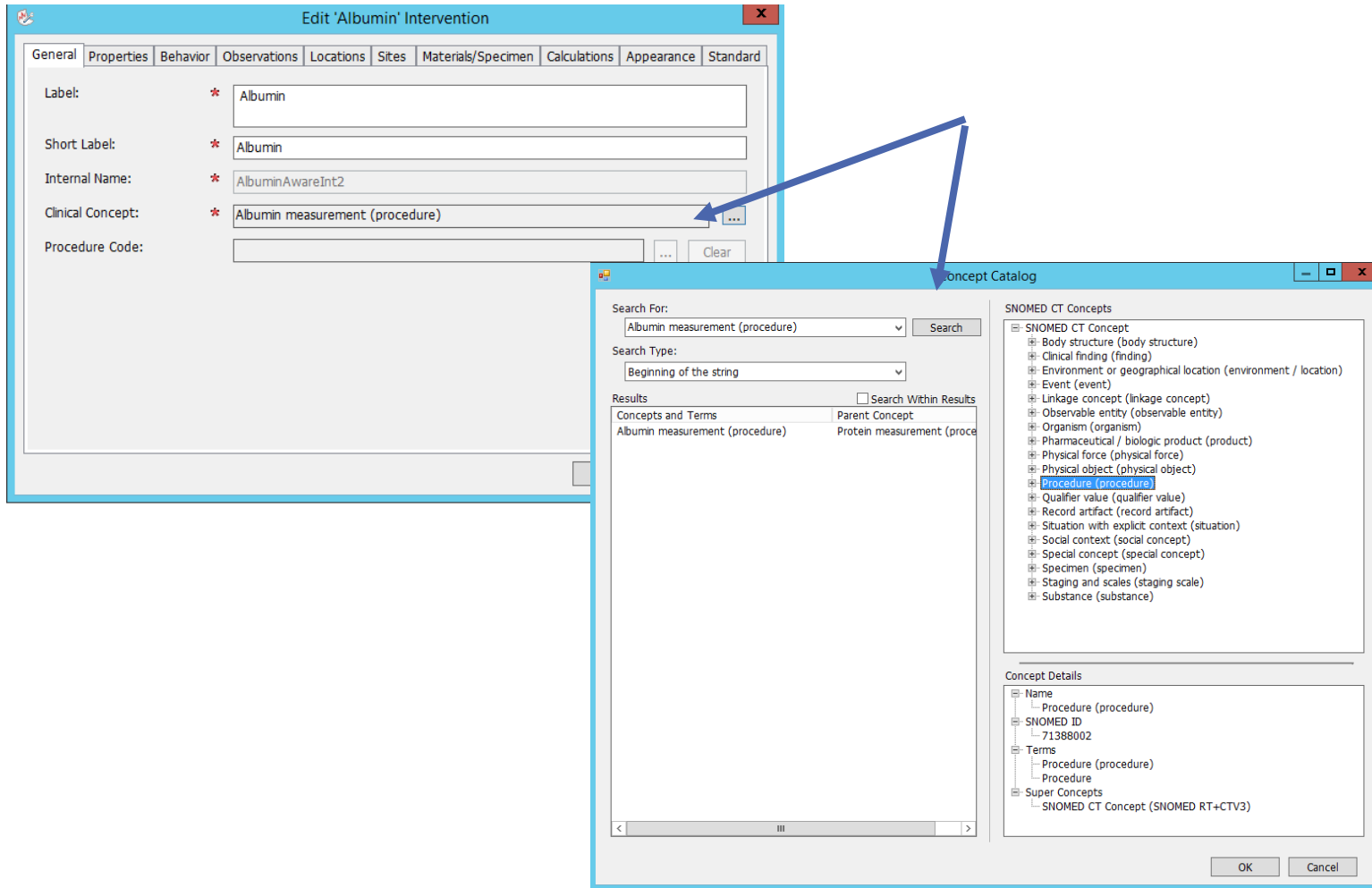


Patient data is mapped to data dictionary interventions for storing into the CDS Engine database using SNOMED CT.

SNOMED CT

SNOMED CT

Results Data Dictionary use of SNOMED CT



All outbound data is identified with SNOMED CT

Configuration Editors allow one to assign SNOMED CT concepts to resulting interventions and attributes for outbound

Example of an Outbound HL7 Message

MSH|^~\&|System.CIS.PatientResult.BL^PAPAppSvr1^DNS|Philips.CIS.CVC|||20150825181014||

PID|||04Aug_29^^^System.CIS.ADT^MR||9E0B829A514C4CB48B7E0A8B012F6127

PV1|||1_3^^1_3_7_7

OBR|1|||26758005^Albumin^SNM|||20150825180600|||2.7 20150825220600 Albumin 2.7 25 Aug 2015 18:06####20150825180600 CALC LAB |||||F

OBX|5|ST|278195005^BodySystem^SNM||GI|||N|||F|||20150825180500|^Services^D

OBX|6|ST|371234007^ColorRGB^SNM||rgb(255,255,0)|||N|||F|||20150825180600|^Services^D

OBX|15|ST|26758005^Result^SNM||2.7|||N|||F|||20150825180600|^Services^D

Communication Agent to Application

- **Re-identifies** the patient in the HL7 messages by adding medical record numbers, bed number, etc.
- **Attaches** information that was removed during anonymization
- **Sends** ADT and ORU messages to the CDS Application. All data is identified with SNOMED CT concepts in ORU messages.

CDS Application

- Admits, discharges, and transfers the patients based upon the HL7 ADT messages
- Displays patient information based upon the ORU messages from the CDS engine including
 - Intake and Output totals for current day and as trend over days
 - Patient parameters with their severity status, their age, their most recent value, and their values as a trend over days
 - The status of body systems as normal, abnormal, and critical as icons on the multi-patient view and the single patient view
 - Pertinent diagnostic reports and clinical notes along with their age
 - Key and recent therapies, medications, and procedures, pertinent to critical care

CDS Application

All patient data is stored in the CDS Application database tagged with SNOMED CT concepts

The screenshot displays the CDS Application interface. On the left, a patient dashboard shows cards for several patients: Koot Vivian (17-A), Vacant (18-A), Perry Mary (19-A), Li Jia (20-A), Patorski David (21-A), Michael Paul (16-A), Geary Kevin (15-A), and Smith Lynda (14-A). Each card includes the patient's name, age, and length of stay (LOS). The main area shows a detailed view for Linda Smith (22-A), born 8/17/1926 (76 yrs), with ID 545678567. The interface is divided into several panels: a left sidebar with a 'Navigation Menu', a top section for 'Demographic Information' and 'Allergies Information', a central 'Organ Panel' displaying vital signs and lab results, and a right sidebar with a 'Tools Menu' and a list of medications. A 'Notes Panel' is also visible at the bottom left of the main content area.

Parameter	Value	Unit
HR	95	
ABP Mean	63	
NIAP Mean	65	
LEVORHED	12 MCG/L	
DIGOXIN	0.25 MCG	
DIRENLEPHRINE	20 MCG/L	
VASOPRESSIN	0.02 UNL	
SpO2	92	
PuO2	76	
Art pH	7.57	
Art PCO2	15	
Art HCO3	14	
Art Base Excess	-30.0	

Medication	Dose	Frequency
FENTANYL	50 MCG	
MIDAZOLAM HCL	2 MG	
ETOMIDATE	10 MG	
PRECEDEX	45 MCG	
TRAPROPRIN	0.146	0.200
LACTULOSE	20 GM	
DID-W 1000 ML	1000 MLS	
DEXTROROSE 50%	50 ML	
PROTONIX	40 MG	
LACTULOSE ENEMA	200 GM	
HGB	15.0	
Platelets	360	
HCT	45.5	
HEPARIN SODIUM	5000 UNL	
AQUA-MEPHYTON	10 MG	
Temp	38.3	
WBC	4.41	
Urine WBC	5-10	
Vancomycin Random	14.9	

Not available in the U.S.

In Summary

- The incoming data from hospital systems are mapped to a fixed set of defined SNOMED CT concepts.
- The data, tagged with SNOMED CT concepts, are processed through CDS algorithms by the CDS engine.
- The data is sent to the Applications as HL7 messages with SNOMED CT concepts to be displayed in the applications
- SNOMED CT can be used to normalize diverse inbound patient data and supports the exchange of that data among the components of the CDSS.
- SNOMED CT covers all of the concepts required for the data and the outbound results of the algorithms for these specific algorithms for critical care adult patients

References for more information

Herasevich, V., Gajic, O., and Pickering, B (2013, March 3-7). Information Technology Can Reduce Time Spent on Data Gathering Activities in the ICU. Poster presentation at HIMSS 2013 Physicians Symposium, New Orleans, LA

Manor-Shulman, O., Beyene, J., Frndova, H., & Parshuram, C. S. (2008). Quantifying the volume of documented clinical information in critical illness. *Journal of Critical Care*, 23(2), 245-250.

Olchanski, N., Dziadzko, M.A., Tiong, I.C. et al. (2017) Can a novel ICU data display positively affect patient outcomes and save lives? *J Med Syst* 41: 171. <https://doi.org/10.1007/s10916-017-0810-8>

Pickering, B. W., Herasevich, V., Ahmed, A., & Gajic, O. (2010). Novel representation of clinical information in the ICU: developing user interfaces which reduce information overload. *Appl Clin Inform*, 1(2), 116-131.

Thank You

Questions?

Feel free to contact me with questions at

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