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Representing clinical information in EHR and message standards: analysis, modeling, implementing.

William Goossen RN PhD

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ONTWIKKELING
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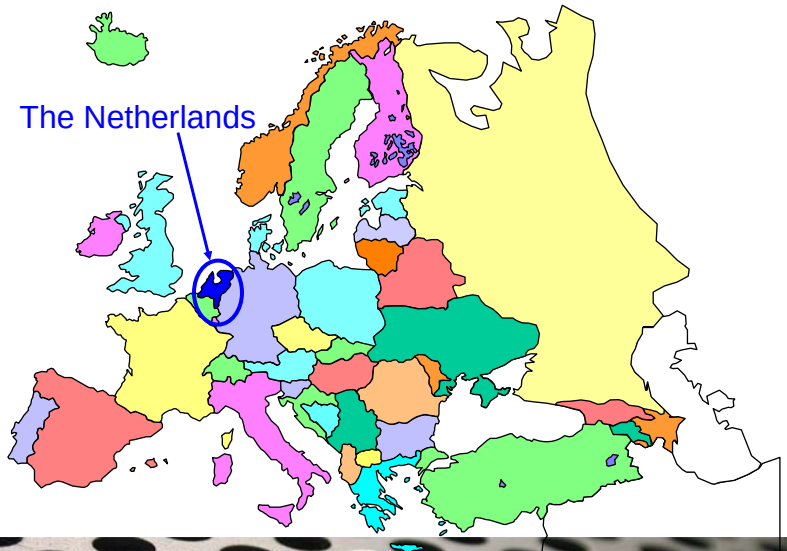

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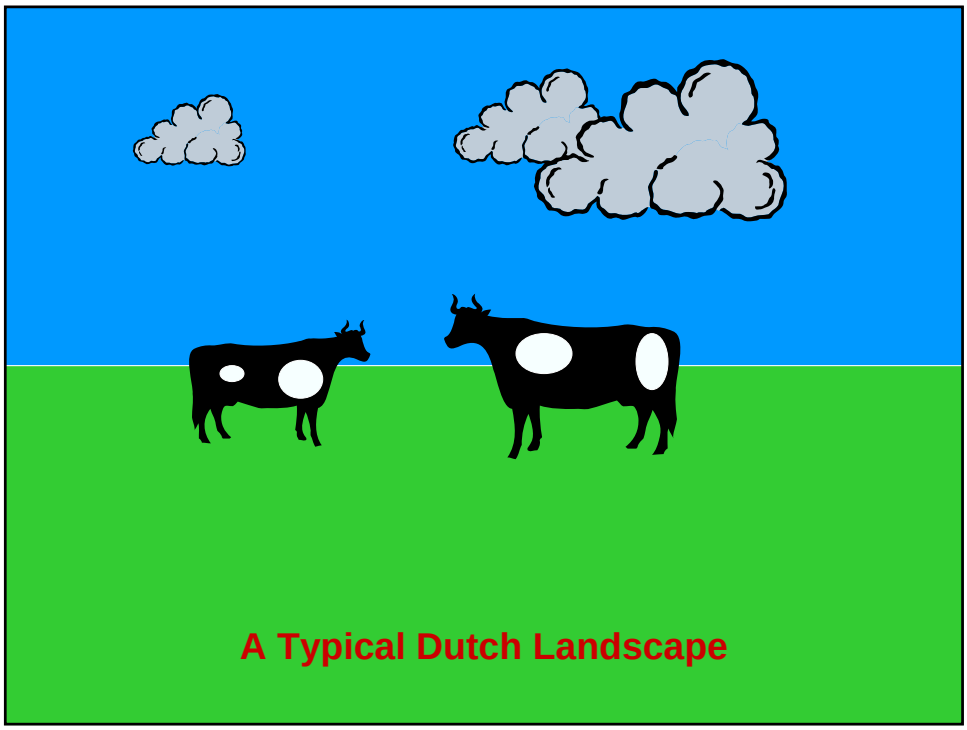
The Netherlands



A Typical Dutch Landscape

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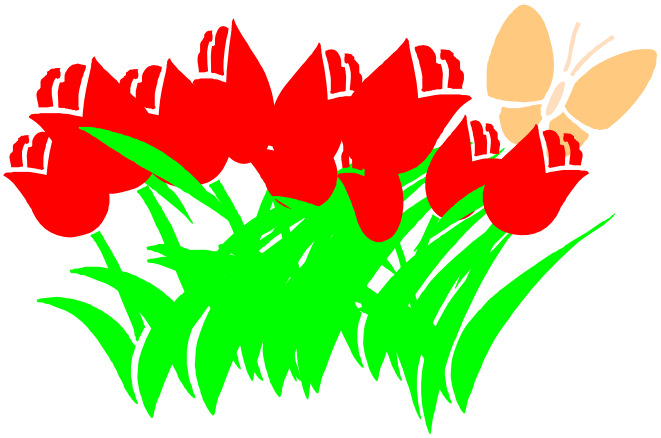
A virtual gift from Amsterdam…



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Another Typical Dutch Landscape


Another typical Dutch landscape

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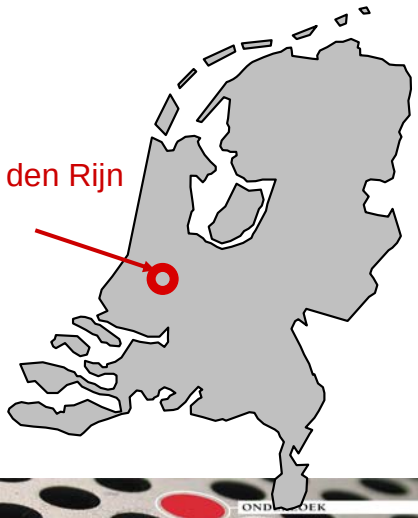

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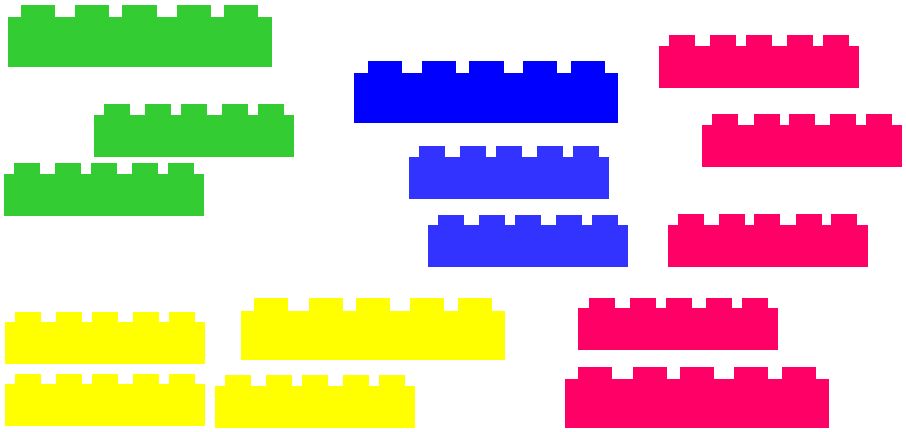
Do you all know LEGO®?



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Easy and difficult

- This is going to be an easy presentation
- But also a little difficult
- I have some pretty complicated (awful!) slides selected!

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Introduction

- Standards: there are **too many** to choose from
- Typology of standards
- Analysis, modeling, implementing
- HL7 v3 as example for information modeling
- Implementation examples:
  - Electronic patient records
  - Message exchange
- Care information models for semantic interoperability
- Conclusions

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Types of standards for healthcare

- Clinical care standards: evidence based practice and guidelines: focus is quality of care
- Terminology: focus is quality of documentation and understanding of meaning
- Information models: focus is (electronic) exchange of information (semantic interoperability)
- Workflow standards: focus is improvement and support of process of care
- Technical standards: focus is quality of technology

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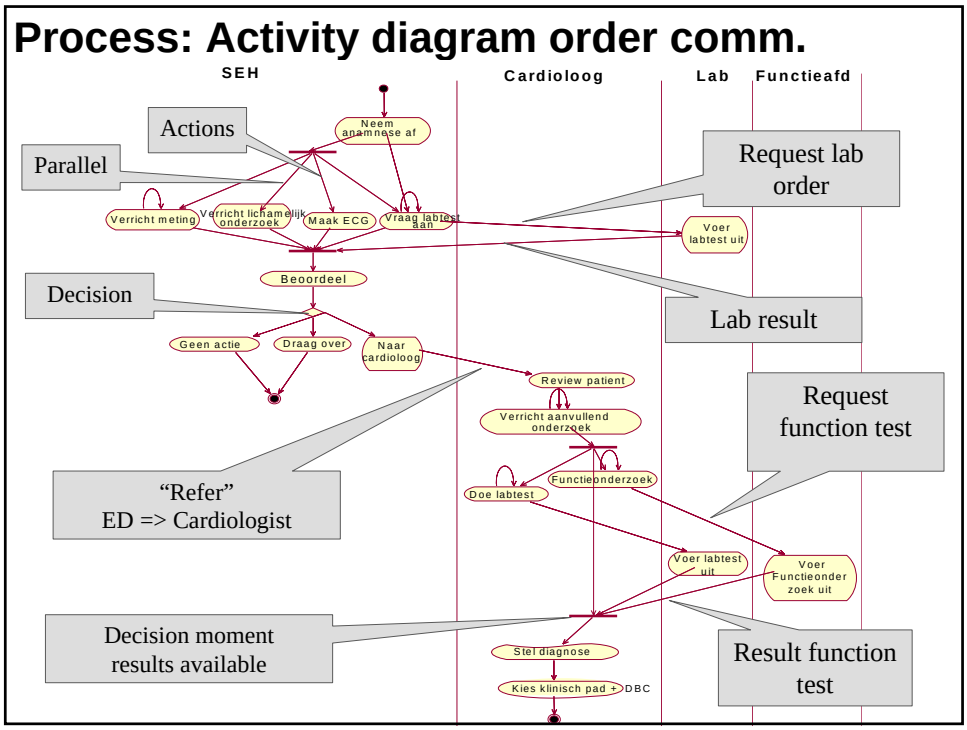
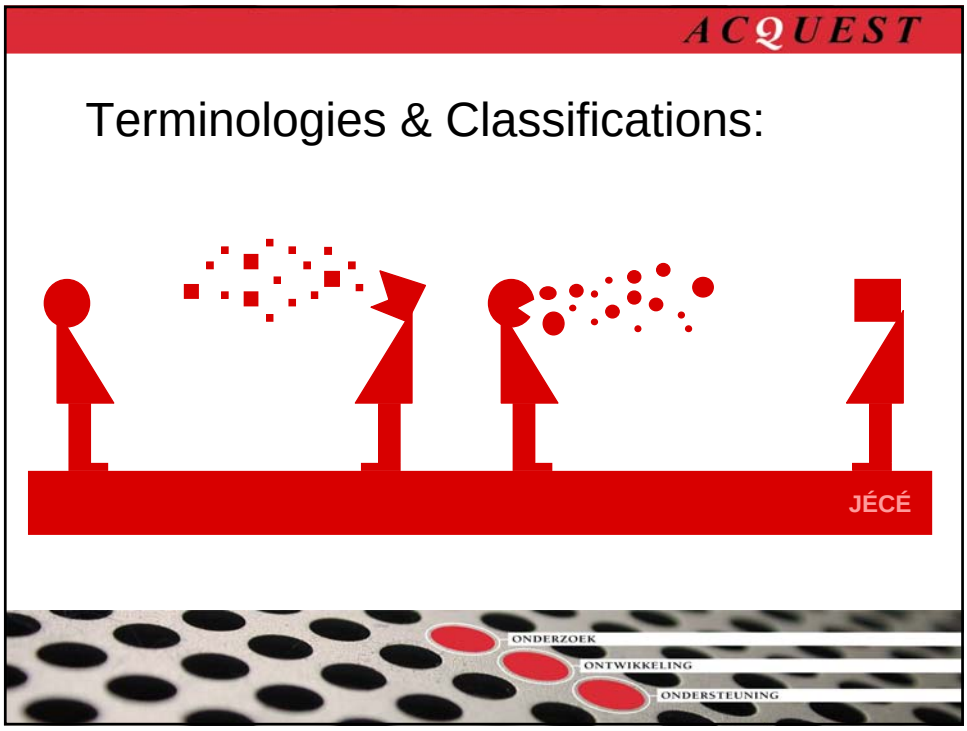
Technical standards: too many to choose from

- TCP/IP
- XML
- SOAP
- WDSL
- IEEE
- UMTS
- W3
- IHE
- NEN 7510
- ISO
- CEN
- OpenEHR
- Etc
- Etc
- Etc
- Etc
- (and their battles as well)


Process: Activity diagram order comm.
SEH
Cardioloog
Lab
Functieafd
Actions
Parallel
Decision
Request lab order
Lab result
Request function test
"Refer"
ED => Cardiologist
Decision moment results available
Result function test
Neem anamnese af
Verricht meting
Verricht lichamelijk onderzoek
Maak ECG
Vraag labtest aan
Voer labtest uit
Beoordeel
Geen actie
Draag over
Naar cardioloog
Review patient
Verricht aanvullend onderzoek
Functieonderzoek
Doe labtest
Voer labtest uit
Voer Functieonderzoek uit
Stel diagnose
Kies klinisch pad + DBC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Terminologies & Classifications:
JÉCÉ
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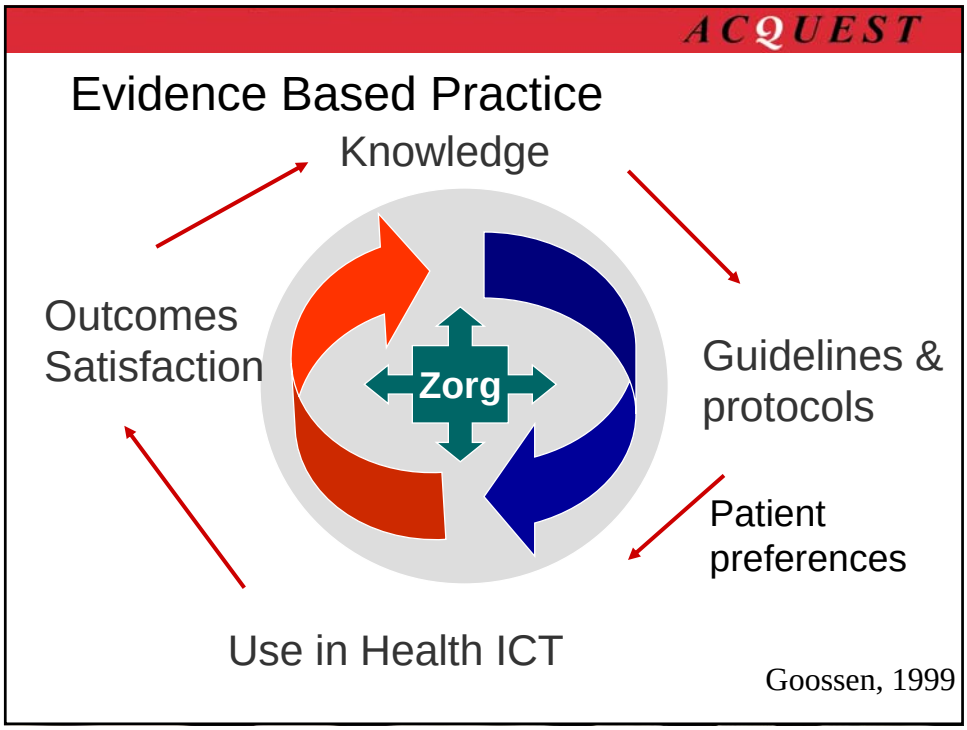
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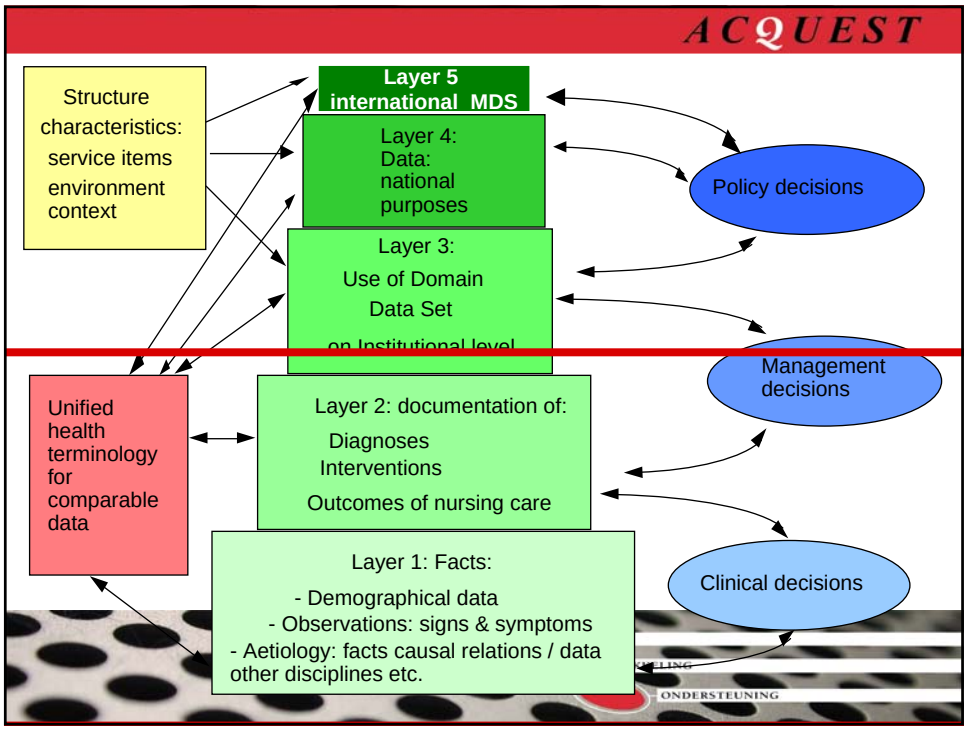
Evidence Based Practice
Knowledge
Outcomes
Satisfaction
Zorg
Guidelines &
protocols
Patient
preferences
Use in Health ICT
Goossen, 1999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Structure
characteristics:
service items
environment
context
Layer 5
international MDS
Layer 4:
Data:
national
purposes
Policy decisions
Layer 3:
Use of Domain
Data Set
Management
decisions
Unified
health
terminology
for
comparable
data
Layer 2: documentation of:
Diagnoses
Interventions
Outcomes of nursing care
Layer 1: Facts:
- Demographical data
- Observations: signs & symptoms
- Aetiology: facts causal relations / data
other disciplines etc.
Clinical decisions

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Analysis

- **Information analysis**: data, proces, communication, formalization, decisions etc.
- **Proces or workflow**: who is doing what when with what result for a patient?
- What **knowledge** is or should be applied when in the course of action?
- What appropriate **decisions** must be made?

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Examples clinical standards

- Atomic observations, e.g. vital signs, heart rate, skin color
- Assessments like ADL, Pain score, Barthel index
- Risk scales, like pressure ulcer risk, risk for falls
- Monitoring tools, like tracking vital signs
- Clinical guidelines, like how to prevent errors

- Focus: standards for professional quality and use of evidence based materials.

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Vocabulary used

- Terminology & classifications, like ICD 10, ICF, DSM – IV, NANDA, ICNP, SNOMED CT, LOINC and many clinimetric instruments having their own wording
- Most are developed purpose oriented
- Data sets: what do you need in the documentation for patient category A?
- Professional organizations deal with it

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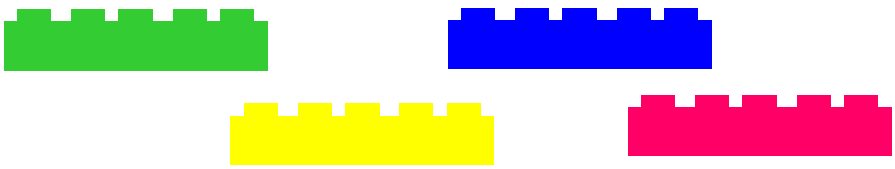
How to play with LEGO®? Part 2



Next slide: My box of Bricks and tricks!

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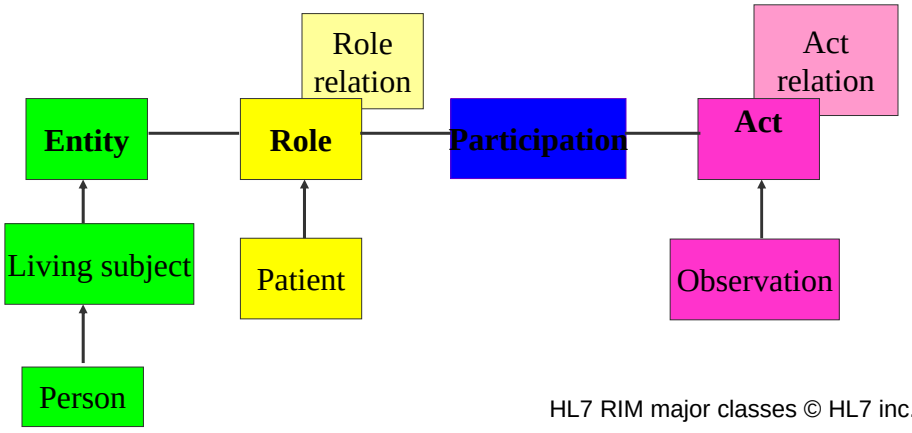
HL7 v3 Standard for clinical data exchange



HL7 RIM major classes © HL7 inc.

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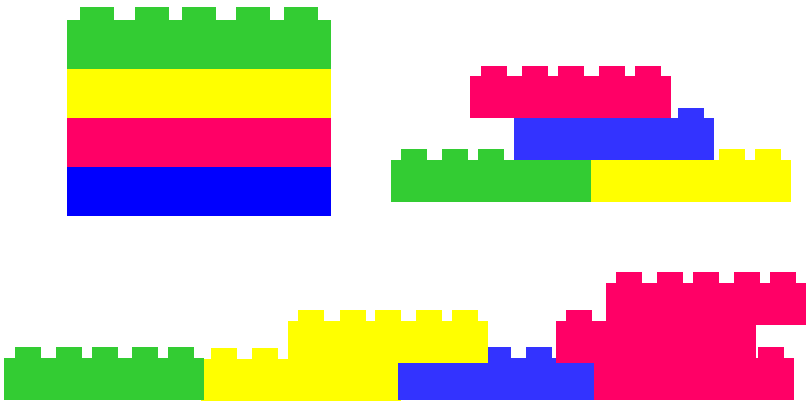
How to play with LEGO®? Part 3 for advanced players



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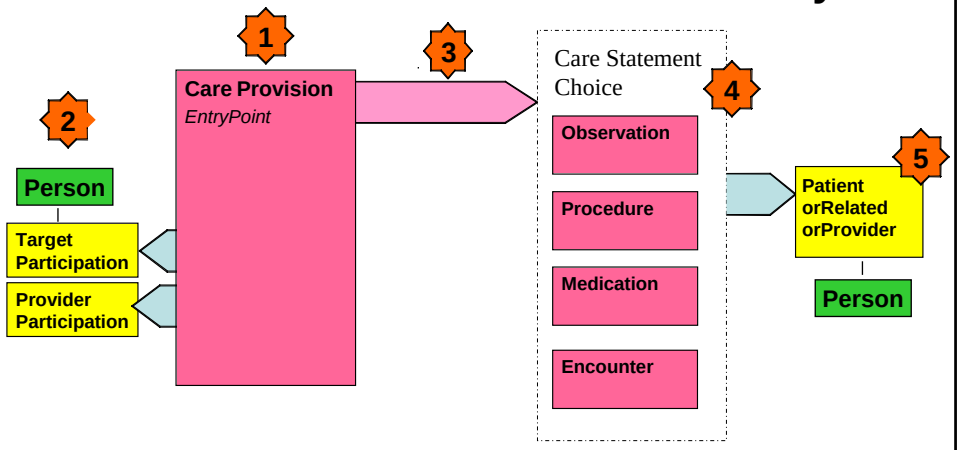
HL7 v3 Care Provision model summary



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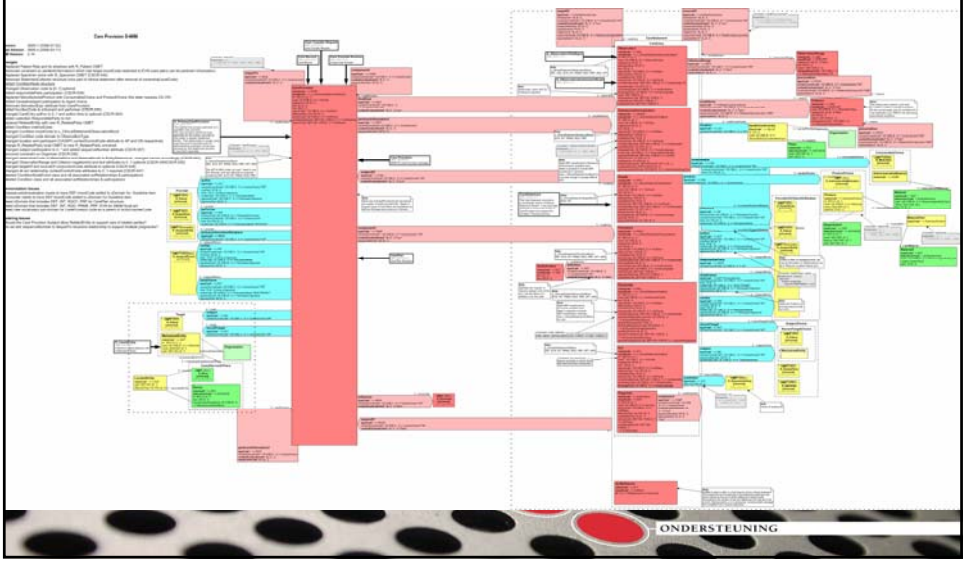
HL7 v3 Care Provision sept 06 ballot



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Single observation model

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Vitals model: Single Observation

Hartslag
(UUDD_RMnnnnnn)
Description

Heartbeat

Hartslag
classCode*: <= *OBS*
moodCode*: <= *EVN*
code: CD CWE [0..1] <= *ActCode* "LOINC 8867-4"
derivationExpr: ST [0..1]
effectiveTime: GTS [0..1]
value: INT [0..1]
interpretationCode: SET<CE> CWE [0..*]
<= *ObservationInterpretation*
methodCode: SET<CE> CWE [0..*] <=
ObservationMethod

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Example pain score

Pijnscore_Meting
(Acquest Februari 2005)
Doc_Obs_Pijnscore_Meting_V.0.7

Pijnscore_Meting
classCode*: <= *OBS*
moodCode*: <= *EVN*
code: CD CWE [1..1] <= *PijnMeting*
effectiveTime: GTS [0..1]
value: INT [1..1]
interpretationCode: SET<CE> CWE [0..*]
<= *ObservationInterpretation* "0 = geen pijn, 10 = ergst denkbare pijn"
methodCode: SET<CE> CWE [0..*]
<= *ObservationMethod*
(Vraag patient om ernst van pijn in cijfer uit te drukken op de lineaal.)

- Moodcode Def = guideline
- Moodcode Int = add to care plan
- Moodcode EVN = measure
- Effective time: 24 November 12.00 hr.
- Value = 8
- Etc.

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Nursing Diagnoses
(UUDD_RMnnnnnn)
Description

Nursing Diagnoses
classCode*: <= *OBS*
moodCode*: <= *EVN*
code: <= *ActCode* "PROBLIST"
effectiveTime:
value: CE CWE [0..1]
methodCode: <= *ObservationMethod*
(Determine the appropriate nursing diagnoses and use the right description from the problem list)

Example HL7 v3 use for nursing diagnoses in problem list

Mapping Domain Data, Vocabulary and HL7 R-MIM

Variable	DMIM	attribute	Data type HL7	Cardinality	Vocabulary	Code	Example
Nursing diagnosis	OBS	value	CE	0..1	NANDA	***	Acute Pain
Nursing diagnosis	OBS	value	CE	0..1	ICNP	1A.1.1.1.13.1 & 1D.1	Pain & Acute
Nursing diagnosis	OBS	value	CE	0..1	ICF	d420	Change positions

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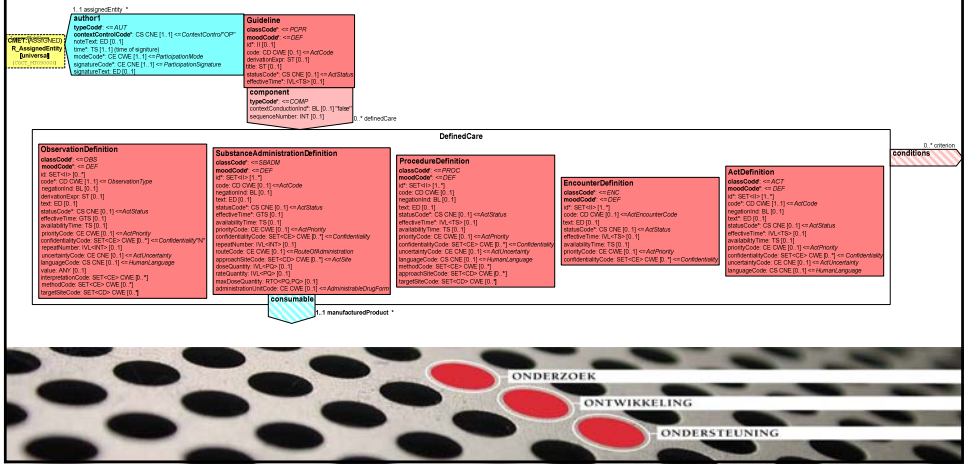
Guideline

Definition of observation: what to measure when

Observatie in Goal Mood = expected result

Measurement of Observation x = Event mood



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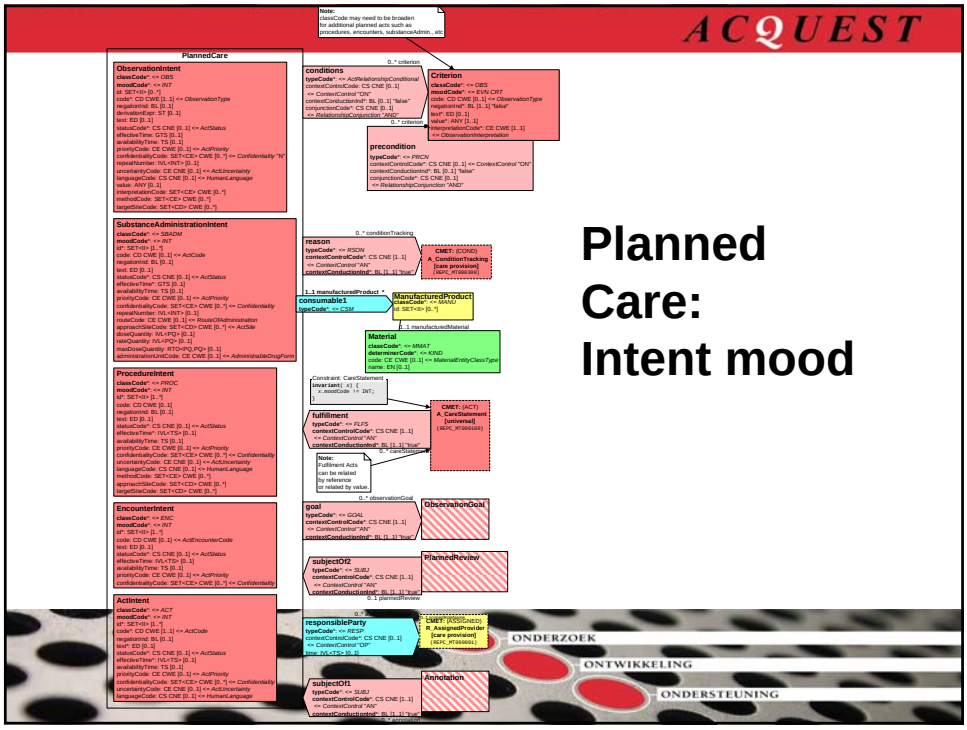

Planned Care: Intent mood

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How combining it all?

- Knowledge
- Data items
- Vocabulary
- Coding
- Values
- etc

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- **Template Name: Scale 'risk for pressure ulcer'**
- Template Code: 'Acquest 00001'
- Creator: William Goossen
- Creation dat": August 2002
- Version: 1.0
- Instantiation: of HL 7 RIM class: 'Observation'
- Part of: Nursing process model ' Findings' as developed at the nursing terminology summits
- Description: structured data and vocabulary to represent pressure ulcer scale in information model
- Terminology: ICNP codes 1G.1.2 'High risk for' and 1.A1.1.1.10.3.5.3 'pressure ulcer'
- Slot 1: subject: Mobility
  - attributes: Scale 1-4
  - values: completely immobilised = 1, very limited = 2, slightly limited = 3, no limitation = 4
  - terminology: 1A.1.1.1.12.2 'Mobility'; 1B.38.1'Limited' = completely immobilised; 1B.38.1.3 'Limited, to a high degree' = very limited; 1B.38.1.1 'Limited, to a lesser degree' = slightly limited; 1B.38.2 'Not Limited' = no limitation.
- Slot 2: subject: Activity
  - attributes: Scale 1-4
  - values: bedfast = 1, chairfast = 2, walks occasionally = 3, walks frequently = 4 *Etc.*
- Slot 9: attribute: Derivation method: calculation of the sum scores from slots 1 until 8:
  - values: sum score
  - range: between 8 (minimum) and 32 (maximum)

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2004/5 Care information model

- Care information models can be (validated) scales or instruments, observations or actions.
- They represent best practice, are Health Level 7 compliant, support the uptake of standardized terminologies and facilitate technical implementation in both message and clinical information systems.

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Content of a care information model description document

A care information model consists of 12 paragraphs:

- 1: version management
- 2: the aim of the instrument, observation or action.
- 3: the (scientific) foundation or evidence base.
- 4: the variables and their values.
- 5: the instructions for use of the instrument or observation.
- 6: interpretation guidelines.
- 7: references.
- 8: an example of the instrument
- 9: a description of the HL7 model and the model itself.
- 10: the mapping table from the domain to the HL7 Reference Information Model.
- 11: an XML message fragment.
- 12: remarks.

It is open source, some are in English available, translation upon request.

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Limitations of current approach

- HL7 v3 many parts are normative already and have been implemented or tested, however, some parts need further development
- Practical tests have been carried out, including real world implementations in pilot format for Stroke system, however not fully working in daily practice
- Single atomic item has more characteristics than shown: where to place them in the model?
- Work on archetypes / templates harmonization ongoing (however, ego's involved)
- Link to workflow / pathways to be worked out.

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Results: % coverage of SNOMED-CT codes for Stroke CIMs

Amount of care information models	Amount of concepts	Amount of SNOMED CT codes	Percentage of SNOMED CT codes
6 scientific scales	50	13	26%
26 models with individual concepts	157	107	68%
32 in total	207	120	58%

Agreement on 88,1% of the concepts between coder and expert.
For the self made codes 54,9% could be found in SNOMED CT.
And for the codes from an existing coding system 74,4%.

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Results: qualitative Snomed CT - Stroke

- A compound concept does not always relate to one SNOMED CT concept
- Terminology of the clinical area could not be found in SNOMED CT
- Translation of some Dutch items could not be found
- Items with left and right indications
- Level of detail differs
- Cultural differences (use of stimulants is seen as abuse)

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Discussion Snomed CT for stroke

- Several care information models still need to be coded
- The items for the care of stroke patients need a large granularity (very fine grained details)
- Scales have specific clinimetric characteristics, that require an accurate equivalence between the items as used in practice and in the clinical terminology used for the unique coding
- Translations errors and/or cultural differences might be of importance

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SNOMED CT is a useful coding system:

- Sufficient codes could be found, thus improving interoperability
- It is possible to request for inclusion and coding of concepts that could not be found
- Snomed CT has an ongoing project for scale representation that takes the clinimetric aspects of scales and concepts into account
- It is working on further internationalization in order to meet European requirements

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Example care information models

- Barthel index
- Height, Length
- Heartrate, breating rate
- Temperature
- Bloodpressure
- Apgar score
- MMSE
- CES-D depression scale
- Appraxia
- Orientation
- 10 meter walking test
- Ranking scale
- Frenchay Activities index
- Assessment generic
- Family history
- Allergies
- Nursing assessment
- Up to 150 examples available, some in English, most with mapping tables in English available.

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Barthel index

The aim of the Barthel Index is to capture and follow, in a valid and reliable way, the daily activities of the patient, especially the level of depending on help (Mahoney & Barthel, 1965).

Mapping Domain data, Vocabulary and D-MIM

Variables	DMIM	attribute	Data type HL7	Cardinality	Vocabulary	Code	Example	
Barthel Index total score Dutch version!	**OBS**	**value**	**INT**	**1..1**	**CVA-KIS**	**Barthel-index**	**12**	
bowels	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlB525**		
bladder	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlB6202**		
grooming	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlD520**		
toilet use	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlD530**		
feeding	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlD550**		
transfers	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlD420**		
mobility	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlD450**		
dressing	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlD540**		
stairs	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlD460**		
bathing	**OBS**	**value**	**INT**	**1..1**	**"**	**BrtlD510**		

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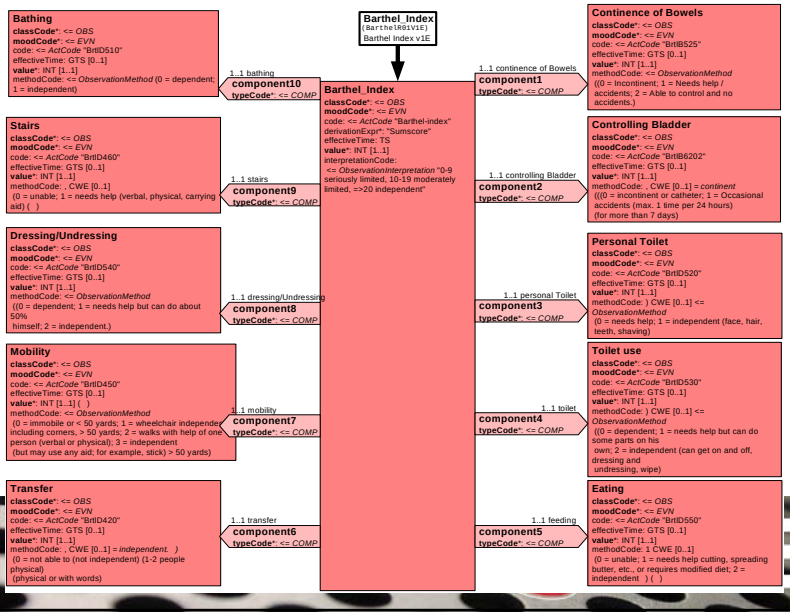
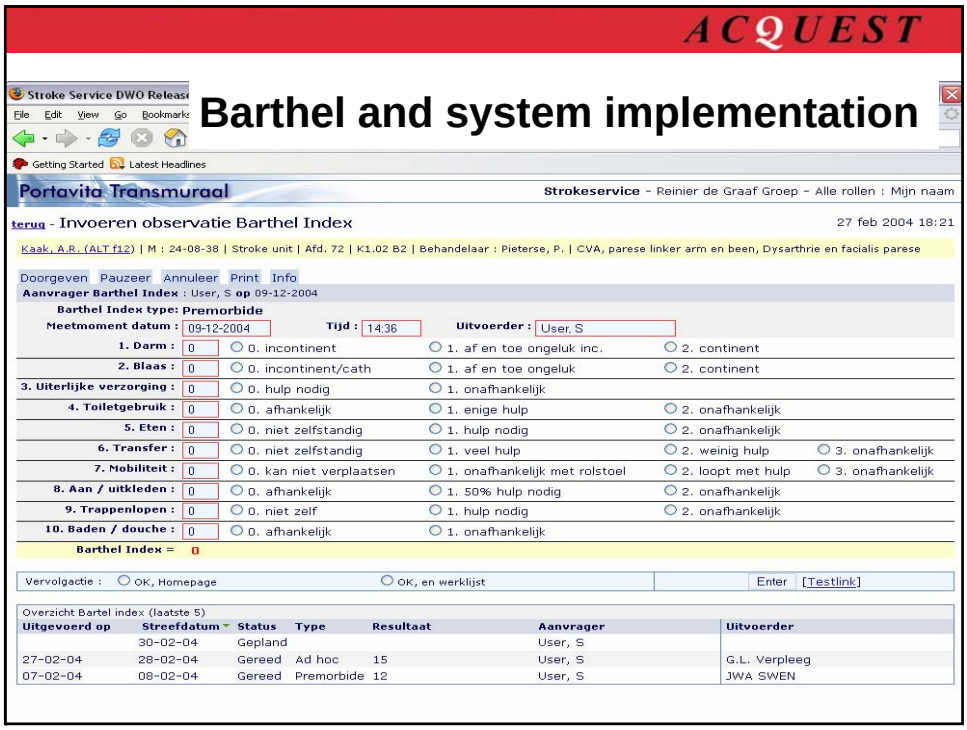
Barthel index Care Statement model

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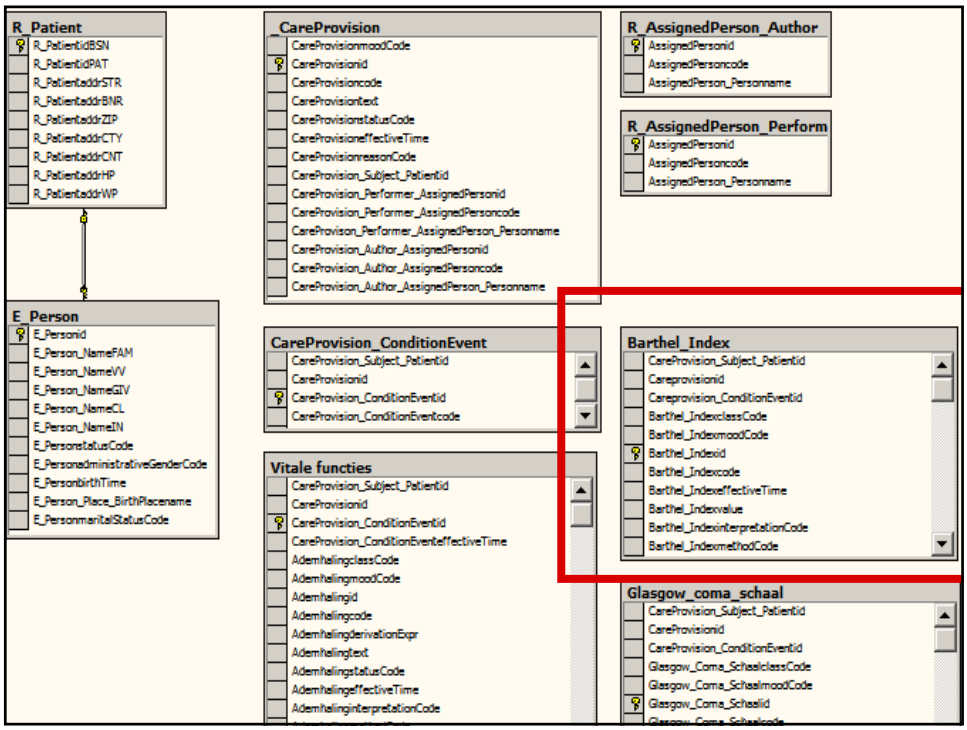
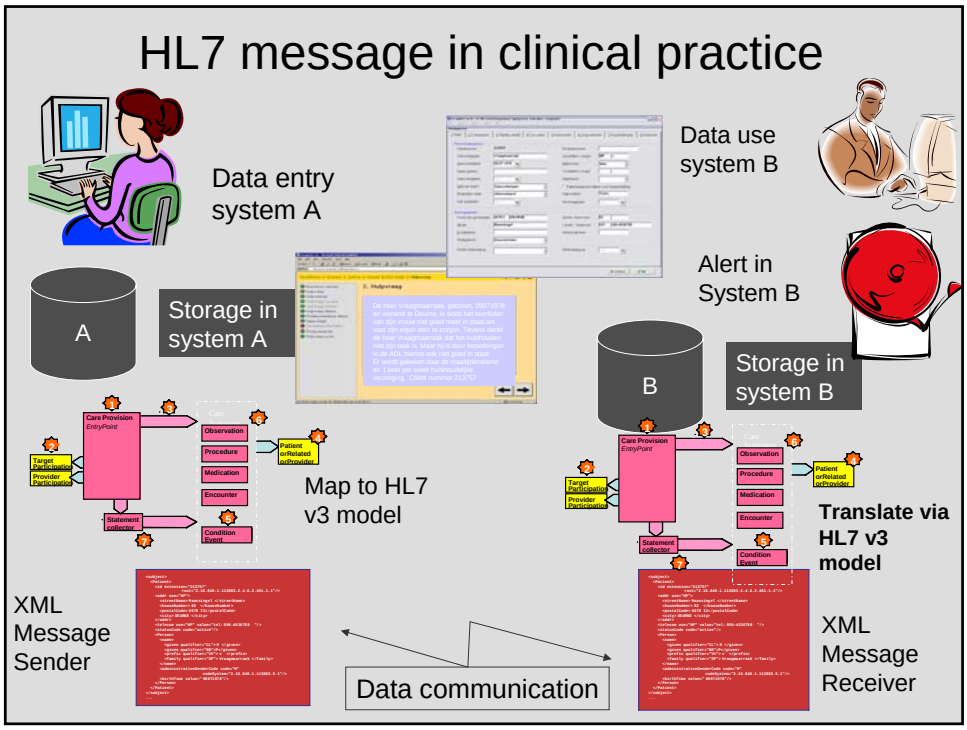
Barthel and system implementation
Stroke Service DWO Release
File Edit View Go Bookmarks
Getting Started Latest Headlines
Portavita Transmuraal
Strokeservice - Reinier de Graaf Groep - Alle rollen : Mijn naam
terug - Invoeren observatie Barthel Index
27 feb 2004 18:21
Kaak, A.R. (ALT f12) | M : 24-08-38 | Stroke unit | Afd. 72 | K1.02 B2 | Behandelaar : Pieterse, P. | CVA, parese linker arm en been, Dysarthrie en facialis parese
Doorgeven Pauzeer Annuleer Print Info
Aanvrager Barthel Index : User, S op 09-12-2004
Barthel Index type: Premorbide
Meetmoment datum : 09-12-2004 Tijd : 14:36 Uitvoerder : User, S
1. Darm : 0 0. incontinent 1. af en toe ongeluk inc. 2. continent
2. Blaas : 0 0. incontinent/cath 1. af en toe ongeluk 2. continent
3. Uiterlijke verzorging : 0 0. hulp nodig 1. onafhankelijk
4. Toiletgebruik : 0 0. afhankelijk 1. enige hulp 2. onafhankelijk
5. Eten : 0 0. niet zelfstandig 1. hulp nodig 2. onafhankelijk
6. Transfer : 0 0. niet zelfstandig 1. veel hulp 2. weinig hulp 3. onafhankelijk
7. Mobiliteit : 0 0. kan niet verplaatsen 1. onafhankelijk met rolstoel 2. loopt met hulp 3. onafhankelijk
8. Aan / uitkleden : 0 0. afhankelijk 1. 50% hulp nodig 2. onafhankelijk
9. Trappenlopen : 0 0. niet zelf 1. hulp nodig 2. onafhankelijk
10. Baden / douche : 0 0. afhankelijk 1. onafhankelijk
Barthel Index = 0
Vervolgactie : OK, Homepage OK, en werklijst Enter [Testlink]
Overzicht Bartel index (laatste 5)
Uitgevoerd op Streefdatum Status Type Resultaat Aanvrager Uitvoerder
30-02-04 Gepland User, S
27-02-04 28-02-04 Gereed Ad hoc 15 User, S G.L. Verpleeg
07-02-04 08-02-04 Gereed Premorbide 12 User, S JWA SWEN


R_Patient
R_PatientidBSN
R_PatientidPAT
R_PatientaddrSTR
R_PatientaddrBNR
R_PatientaddrZIP
R_PatientaddrCTY
R_PatientaddrCNT
R_PatientaddrHP
R_PatientaddrWP
E_Person
E_Personid
E_Person_NameFAM
E_Person_NameVV
E_Person_NameGIV
E_Person_NameCL
E_Person_NameIN
E_PersonstatusCode
E_PersonadministrativeGenderCode
E_PersonbirthTime
E_Person_Place_BirthPlacename
E_PersonmaritalStatusCode
_CareProvision
CareProvisionmoodCode
CareProvisionid
CareProvisioncode
CareProvisiontext
CareProvisionstatusCode
CareProvisioneffectiveTime
CareProvisionreasonCode
CareProvision_Subject_Patientid
CareProvision_Performer_AssignedPersonid
CareProvision_Performer_AssignedPersoncode
CareProvison_Performer_AssignedPerson_Personname
CareProvision_Author_AssignedPersonid
CareProvision_Author_AssignedPersoncode
CareProvision_Author_AssignedPerson_Personname
CareProvision_ConditionEvent
CareProvision_Subject_Patientid
CareProvisionid
CareProvision_ConditionEventid
CareProvision_ConditionEventcode
Vitale functies
CareProvision_Subject_Patientid
CareProvisionid
CareProvision_ConditionEventid
CareProvision_ConditionEventeffectiveTime
AdemhalingclassCode
AdemhalingmoodCode
Ademhalingid
Ademhalingcode
AdemhalingderivationExpr
Ademhalingtext
AdemhalingstatusCode
AdemhalingeffectiveTime
AdemhalinginterpretationCode
R_AssignedPerson_Author
AssignedPersonid
AssignedPersoncode
AssignedPerson_Personname
R_AssignedPerson_Perform
AssignedPersonid
AssignedPersoncode
AssignedPerson_Personname
Barthel_Index
CareProvision_Subject_Patientid
Careprovisionid
Careprovision_ConditionEventid
Barthel_IndexclassCode
Barthel_IndexmoodCode
Barthel_Indexid
Barthel_Indexcode
Barthel_IndexeffectiveTime
Barthel_Indexvalue
Barthel_IndexinterpretationCode
Barthel_IndexmethodCode
Glasgow_coma_schaal
CareProvision_Subject_Patientid
CareProvisionid
CareProvision_ConditionEventid
Glasgow_Coma_SchaalclassCode
Glasgow_Coma_SchaalmoodCode
Glasgow_Coma_Schaalid



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Barthel and HL7 v3 XML message

```
<!--  Total score on Barthel Index stroke service  -->
  - <Observation moodCode="EVN">
        <id />
        <code code="Barthel-index "
              codeSystem="2.16.840.1.113883.2.6.15.1" />
          <statusCode code="completed" />
          <value xsi:type="INT" value="14" />
        - <entryRelationship typeCode="COMP">
          - <!-- Bowels     -->
    - <Observation moodCode="EVN">
        <id />
            <code code="PREMBrtlB525"
              codeSystem="2.16.840.1.113883.2.6.15.1.ICFXXX" />
              <statusCode code="completed" />
        <value xsi:type="INT" value="2" />
            </Observation>
          </entryRelationship>
          - <entryRelationship typeCode="COMP">
```

ACQUEST

Barthel and Archetype (S. Heard)

```
definition
   OBSERVATION[at0000] matches {    -- Barthel Index
      data matches {
         HISTORY[at0002] matches {    -- *history(en)
            events cardinality matches {1..*; ordered} matches {
               EVENT[at0003] occurrences matches {0..*} matches {    -- *Any event(en)
                  data matches {
                     List[at0001] matches {    -- *structure(en)
                        items cardinality matches {0..1; ordered} matches {
                           ELEMENT[at0004] occurrences matches {0..1} matches {    -- Darm
                              value matches {
                                 ORDINAL matches {
                                    value matches {
                                       0|[local::at0005],    -- incontinent of catheter
                                       1|[local::at0006],    -- af en toe een ongelukje (max. 1 keer per 24 uur)
                                       2|[local::at0007]     -- continent (gedurende meer dan 7 dagen)
                                    }
                                 }
                              }
                           }
                        }
                     }
                  }
               }
            }
         }
      }
```

ACQUEST

Summarizing with an example from table with clinical knowledge via model to implementation

Functional Ambulation Categories:

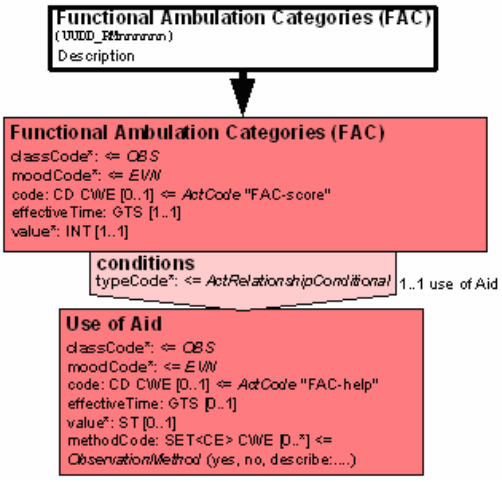
- Mapping Table with clinical item, vocab and coding
- Hl7 model
- Screen for stroke system

ACQUEST

Variables of FAC	**Place in HL7 RIM class**	**Data type HL7**	**Score** (value attribute)	**stroke-EPR Vocabulary & Code** (code attribute)
Use of aid	OBS: value code	ST (string)	Free text	FAC-help
FAC score	OBS: value code	INT (integer)	FAC 0 = Not or not functional FAC 1 = Dependent (level II) FAC 2 = Dependent (level I) FAC 3 = Supervision FAC 4 = Independent but limited FAC 5 = Independent and unlimited	FAC-score

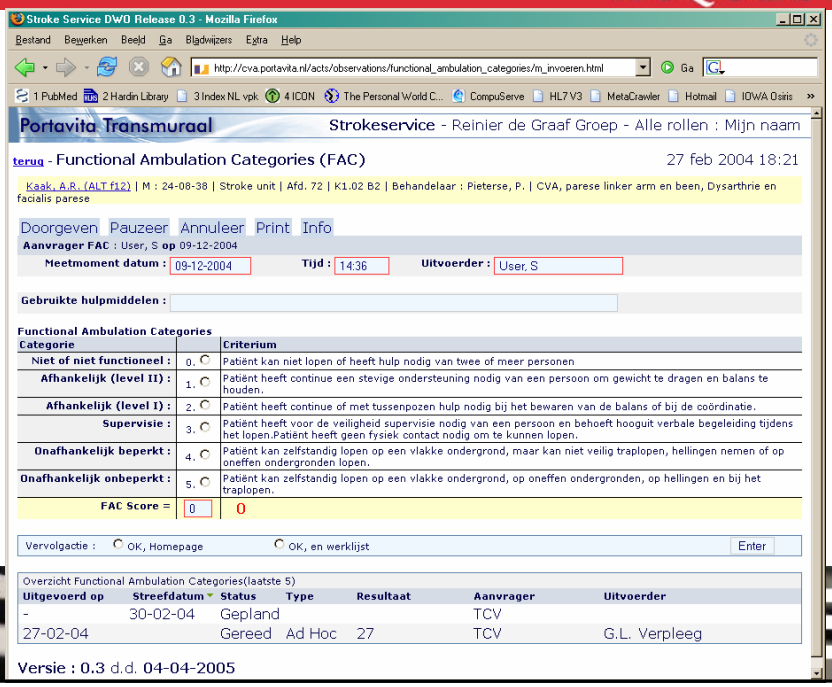
ONDERZOEK
ONTWIKKELING
ONDERSTEUNING

ACQUEST



ONDERZOEK
ONTWIKKELING
ONDERSTEUNING

ACQUEST



ACQUEST

Can you play virtual LEGO®?

- As clinician you only have to define the virtual bricks!
- Let standards people and technologists sort it out
- Only pay for the working solution!

ACQUEST

Thank you for your attention

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