eHealth - HS20

Pascal Brunner - brunnpa7

Inhaltsverzeichnis

Kapitel 1

Introduction

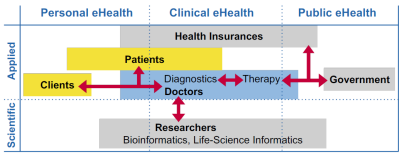

Abbildung 1.1: Show the relationship between the different domains

1.1 What is eHealth?

Supporting and improving the Health industry with ICT

- ICT in healthcare
- Medical records and medical data standards
- Digital imaging
- Telemedicine / Telehealth
- more and more: Big Data is coming even in the healthcare

Some numbers for Switzerland to start

- 80 billion CHF in 2016
- 30000 doctors
- 297 hospitals with 175000 employees, thereof 14000 hospital doctors
- 1700 pharamcies
- more than 2400 nursing homes and care organisation (e.g. Spitex) with 130000 employees
- more than 50 pharma companies with 40000 employees and with 6 mrd
- 61 insurance companies with 12000 employees

What are the typical stakeholders?

- patients
- insurance companies
- pharma industry

- government
- care providers (hospitals, spitex, reha etc.)
- professional guilds (nurses, doctors etc.)

public-private mix

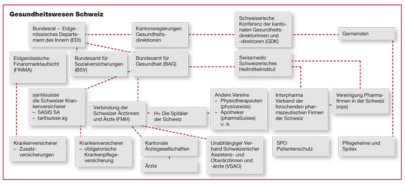

Abbildung 1.2: How does the public private mix look like in Switzerland

Vision of connected Healthcare

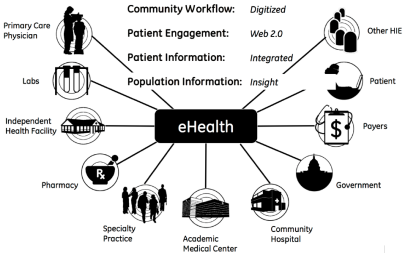

Abbildung 1.3: how does the vision look like?

1.1.1 Opportunities

It is definitely challenging, but the ultimate goal is to improve the quality of health care, researche and education in medicine and health

mid-term

- Digital transformation: ICT tools AND processes
- Electronic Health records and data-driven services
- Digital integration, semantic interoperability, mHealth

long-term

- Individual, personalized medicine (genomics data)
- Longitudinal use of EHR data, data analytics, big data
- Knowledge management, medical DSS, deep learning

1.2 Personal Health

- Get greater quantities of health data to do predictive analytics
- Personal health record (Patientendossier)
- Quantify yourself → Fitness Apps
- Genomic medicine
- move towards personalized medicine

1.3 Clincal Health

- Clinical information systems
- → Electronic medical records and medical vocabularies
- → Laboratory information systems
- Clinical decision-support systems
- Nursing informatics

1.4 public Health

- Regulations, laws and standards → Legal, Quality, Social, Health insurances
- Epidemics, travel medicin → Ebola, Zika, covid ⇒ Analysis the data to identify diseases within a region and with that to get a public health alert
-

Why is it important?

- Healthcare in developed countries is under the biggest 5 industry sectors
- Helathcare in developed countries counts for about 10 % of Gross Domestic Product (BIP)
- costs are growing → grow rate is higher than GDP growth
- In Switzerland we pay 12.2 % of all the money (GDP) for healthcare
- The Age structure is changing → Higher life expectancy (we get older than 80)
- We die after long period with chronic diseaes and this has changed compared to years ago - this is the bad news about living longer
- The costs of healthcare has increased dramatically → Ausgaben wurden seit 1969 verdopplet von 6 auf 12 Prozent
-

1.5 General Practitioner (Hausarzt)

1.5.1 a day in a life

- Family doctor or physician
- typically works in private or group practice
- provides diagnosis and care for patients in routine cases → ambulant care
- usually refers people to specialists when they need specific types of treatment
- has receptionsst and physician assistant

1.5.2 typical workflow

1. Pre-visit: Appointment scheduling and information collection
2. Check-in: patient check-in and payment collection/Health insurance registration
3. Control: rooming, measuring vital signs, patient examination, prescription and result documentation → optional there are some extra lab-tasks e.g. blood test
4. Check-out: patient checkout
5. Post-visit: coding and billing / Reviewing Test results

1.5.3 Clincal Tools

Paper- or IT-based, whether what is used, there are medical records used

- Screening for illness and disease → identify at-risk patents

1.5.4 Medication Management

- Medication errors are the most frequent source of preventable medical errors
- Medication Administration Record
- Electronic Medication Administration records
- Adverse Drug Event → side effect or complication
- Transition points → times when patients move from one location to another
- Medication reconcilation → comparing patients list of medications at admission with medications ordered during hospital stay
- order sets → standardized list of orders for a specific diagnosis e.g. heart disease

What could go wrong?

- Drug-Allergy Conflic
- Drug-Disaese Conflict
- Incorrect Dosage
- Incorrect Duration
- Drug-Pregnancy Conflict
- Drug-Age Conflict
- Drug-Gender Conflict
- Drug-Drug Conflict

→ This could be checked by a electronic drug databases to reduce the errors

1.5.5 Coding and reimbursement

- Documentation and coding plays a major role in whether a payer (health insurance) approves claims and reimburse the physician
- Computer-assisted coding uses software to faciliate claim processiong
- typically country-specific → in Switzerland TARMED (Tarif Médicaux)

TARMED

Overview:

- TARMES is the swiss standard tarif for medical and paramedical services provided in medical practices and hospitals
- since 2004 in every canton
- TARMED tariff comprises about 4600 positions
- Pricing of medical services is calculated consistently throughout Switzerland with so-called tax positions
- However, the amount of remunerations per tax point varies from canton to canton
- These codes from TARMED we will find on our bills from the doctor,

1.6 Current situation / status of healthcare industry

- Physician: still heavily paper-based → to record, store and communicate in hand-written as well as with fax
- Hospitals: core ICT in use → nevertheless there is space for improvement

1.6.1 Why does healthcare lack in ICT

- complexity of care / of healthcare ecosystem → many stakeholders, large number of small org
- Incentives are misaligned → Goals are different; higher quality may not result in more customers
- Data entry effort vs. personal benefit
- Network externality / missing network effects

1.7 Telehealth

Telehealth includes the use of technology to access remote health information, diagnostic imgaes and education

- Email communication
- Refilling prescriptions
- Registering patient
- Scheduling appointments

1.8 Telemedicine

The use of medical information exchanged from one site to another via electronic communications

- Provision of healthcare services through the use of ICT, in situation where patient and health professional are **not** in the same location
- Specialist referral
- Remote patient monitoring
- Store and forward digital images
- Interactive videoconferencing
- Telesurgery

Kapitel 2

Healthcare Information Systems (HIS)

Definition Hospital:
A hospital is ahealth care instituation with an organized medical and professional staff, and with permanent facilities that include in-patient beds. provides medical, nursing and other health-related services to patients
functions

- preventive functions
- curative functions
- trainings functions
- reasearch functions

2.1 Categories of healthcare organizations

2.1.1 Classifcation of health care organizations

- By length of stay
  Short stay (less 24hrs), traditional acute care (1-30d), long-term care
- By type of ownership
  government vs. non-government
- By type of services
  general vs. specialty, community vs. teritary, in-home vs. ambulant

2.1.2 Types of Healthcare organizations

- General hospital
  medical, surgical, emergency
- Specialty hospital
  Psychiatric, women's, children's hospital
- teritary hospital
  complex and unsual problems
- sub-acute care
- in-home health services

2.1.3 Grouping of hospital services

- Administrative services → Management, HR
- Informational services → billing, education, IT
- therapeutic services
- diagnostic services
- support services

2.1.4 Patient Flow in a hospital

1. Registration and scheduling
2. nursing situation
3. ancillary services
4. surgey
5. ... until patient is ready to be discharged

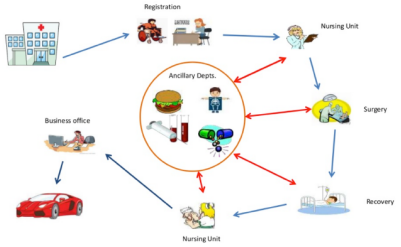

Abbildung 2.1: how does the inpatient flow look like

2.2 Information systems in healthcare organizations

2.2.1 Complexity of ICT at hospital

- Practitioners' offices typically maintain one Clinical information system
- have numerous clinical information systems (Laboratory, pharmacy, radiology systems etc.)
- Need for interoperability and integration

⇒ A HIS is really complex not only in the functions but also in the GUI

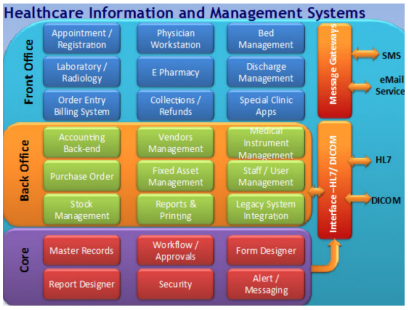

Abbildung 2.2: Healthcare information and management systems

2.2.2 Main Functions from a HIS

There are two types

- clincal support
- Administrative support

We need all information and have directly access to the information, to get a better documentation and improve the quality of care.
Especially to reduce to errors in daily business and improve the productivity and efficiency.

Clincal Support

Nursing
Support the daily business of a nurse e.g. view and update vital data, access to drug info
Goal: Documentation access to info, productivity and communications, regulatory compliance

Monitoring
monitor the patients and alert immediately if there is an abnormal finding e.g. real-time monitoring, automatically feeding into the CIS

Order Entry
Direct entry of orders for medication and transmit orders online (e.g. pharmacy, Laboratory, radiology, social services, ...)

Laboratory
so-called *Laboratory Mangement System* to provide

- Manage lab test
- alert if a test results is critical
- Send results to CIS
- Accept inputs from bedside devices
- Use rules to order additional tests
- Address issues such as turn-around time, duplicates, errors

LOINC Standard Logical Observation Identifiers Namens and codes

Radiology
Should provide the functions to support the daily business such as

- allow direct order
- Scheduling diagonstic test
- generate client instructions
- permit transcription of results
- provide picture archiving
- generate charges once procedures are done

Picture Archiving and Communication Systems (PACS): Images from X-Ray/CT/MRI devices transferred PACS which is linked directly to the CIS. And provide directly access to results and searching

Pharmacy (eMedication / ePrescription)

- provide checks in order
- administration process using evidence-based guidelines
- Barcode and RFID Medication administration
- Dispensing systems
- Use lab results, allergy and interaction information from CIS
- track medication use, costs and billing information

Electronic Medication Administration Records (eMAR) the main goal is to eliminate errors.

Administrative Information Systems

It is a very often scenario that a hospital runs two different system, one for the CIS and one for the Admin-part
Patient and Client Registration

- admission, discharged and Transfer (ADT) systems
- Collect and sotre demographic and insurance data
- critical to opersionts to ensure correct patient identification
- One of the most important part is how to identify the patient (Barcode etc.)

Financial Systems

- Charge all services
- provide data for insurance
- financial controlling
- generate reports

Payroll and Human Resources

- Payroll
- Contracting
- Career planing
- Physical access control (key, badge etc)

Risk Management

- risk monitoring
- reduce risk

Quality Assurance

- Management Cockpit
- Decision Support Systems

Contract Management

- provide visibility and control to negotiate better contract with vendors etc.

Scheduling Systems

- Planning appointments
- Staff Planning
- insurance approval
- charging information

Other Admin Systems

- IT Security Management
- Facility Management
- Roles and Access Rights Mgmt

⇒ The IT-Security Part is one of the most important and fragile parts in a hospital. If a hospital gets hacked, there are a lot of consequences and it can decide between life and death.

Kapitel 3

EHR

Electronic Health Record conforms to nationally recognized interoperatibility standards, **across more** than one organization

3.1 Electronic Medical Record

- typically created in hospitlas and ambulatory environment using HIS
- Case-based: single encounter of treatment
- structured data (predefined format with discrete data encoding)
- to provide patient care, communication, legal documentation, billing etc.
- Content examples: identification, problem-list, progress notes, lab reports, discharge summary

3.2 Adaoption Model

1. Stage 0
   all paper based
2. Stage 1
   all three major ancillaries installed - laboratory, pharmacy and radiology
3. Stage 2

4. Stage 3
   Clinical documentation installed
   First Level of clinican decision support is implemented to conduct error
   Image access from picture archive and communication system (PACS)
5. Stage 4
6. Stage 5
   closed loop mediciation administration environment is fully implemented
   Using eMAR (barcode)
7. Stage 6
8. Stage 7
   fully paperbased

3.3 EHR

- Comprehensive lifetime health record
- manages episodic and longitudinal information
- patient-oriented health data

3.3.1 purpose

- Continuity of care documentation (CCD)
- engage patients and Family
- maintain privacy and security of patient health information
- improve care coordination and population and public care

3.3.2 Content of EHR

- personal and family health data
- vaccinations (Impfbuch)
- Allergies
- medication record
- health data
- fitness and mental data (sensors, self-recorded)
- physician's order, treatment plans, diet plans
- medical images and reports
- laboratory reports
- consents and authorization forms (Stoffwechsel)
- Pathology and operative reports
- Health history summary, dashboard, analytics, visualisation

3.3.3 Issues in EHR Implemntation

- EHR Infrastructure
- Common Vocabulary
- Data Integrity
- Data ownership

  Who is the owner of the data

  Patients own their data and should have full access
- Privacy and Confidentiality
- Development and Maintance costs

  Who will pay? government, insurances, patients?
- caregiver resistance
- political System

Kapitel 4

Health Data - Standards and Ontologies

4.1 HIS related

4.1.1 Challenges

- Hospital is a huge organisation → many departments, people, stakleholders and activities
- demand for good information → the right content in the right time at the right time to a specific user
- distribution of data and knowlege → many different sources, location and systems create a lot of data (structured and unstructured)

4.1.2 Usability Issues

- Interference with patient visit
- Lack of system-design support for team-based care
- care coordination due to lack of data interoperability
- increased cognitive workload for physicians
- lack of product modularity to support unique needs
- lock-in to systems
- communicating with patients in a changing digital landscape
- insufficient support for enduser

4.2 Types of data

Clinical Data

- clinical or health-related information used by providers in diagnosing, treating and monitoring
- case-based: illness, accident
- life-cycle-oriented: medical health record

administrative Data

- primary purposes on the administrative data side is billing
- dealing with diagnosis codes and procedure codes → TARMED or SwissDRG

4.3 Entering Data into a HIS

There a various ways to enter the data into a HIS. The data will be enter by a desktop computer (after consultation or discharge) or mobile device (bed-side)

- manual typing
- clinical templates
- dictation and transcription
- voice recognition
- scanning and OCR
- touchscreen

4.4 Metadata

data about data - there are different levels of metadata and therefore different Complexity

- Schema → Definition of data format (e.g. XML Schema)
- Vocabulary → allowed values, code translation
- Classifcation → topic-oriented type hierachy
- Taxonomy → controlled vocabulary with structured directory of terms
- Thesaurus → map words to concept
- Ontology → Model of a domain with rules and it is a knowledge representation which is machine-readable

4.4.1 Semantic gap

Since words has different meaning in a specific context sometimes it is not clear what is meant. Therefore it's a **semantic gap** between words and concept
e.g.: Double Bass = Upright Bass = Contrabass (synonym) or fruit ← Apple → Company
⇒ Thesauri and onotlogies manage semantic

4.4.2 Categorization

Generalization vs. Specialization → we typically learn basic level (e.g. Chair, Table) categories first

- we get more precise with subcategories → Hyponym (Unterbegriffe) and subordinate (untergeordnet) e.g. dining chair, kitchen table
- we get more abstract with supercategories → hypernyms (Oberbegriff) and superordinate (übergeordnet) e.g. furniture

4.5 Clinical Information Standards

4.5.1 Classication Systems

- International Classifcation of Diseases, Ninth Revision (ICD-9)

- International Classifcation of Diseases, Tenth Revision (ICD-10)

  Current Procedural Terminology (CPT)

  Healthcare Common Procedures Coding System (HCPCS), Level II

- Anatonmical Therapeutic Chemical (ATC) Classifcation

  Classifies therapeutic drugs

4.5.2 Clincal Vocabularies and Ontologies

- SNOMED-CT - *Systematzied Nomenclature of Medicine Clinical Terms*

  Identifies atomic entities such as chemicals, diagnoses, findings, anatomic sites and organisms

- LOINC - *Logical Observation Identifiers Namens and Codes*

  Identifies laboratory tests, clinical variables and survey instruments

  for recording single observation, measurement, test result

- UMLS - *Unified Medical Language System*

  By the US National Library of Medicine (NLM)

- RxNorm - *US specific terminology, part of UMLS*

  Identifies the clinical drug and its component, ingredients, dose form etc.

SNOMED-CT

- Systematzied Nomenclature of Medicine Clinical Terms
- Codes, terms, synonyms and definitions covering anatomy, diseases, findings, procedures etc
- globally recognized ontology
- needs license → Siwtzerland applied to become offical member (started first a test phase)

SNOMED-CT Coding Clinical Terms Identifer (SCTID)

- SNOMED-CT Clinical Terms Identifer (SCTID)
- Sequence of 6 to 18 digits that identifies a component
- directed acyclic graph

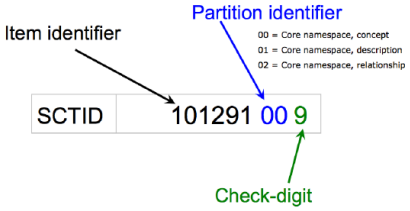

Abbildung 4.1: example for SCTID

SNOMED-CT Ontology Structure

- Combing isa-hierarchy and attribute relations

  ISA classification hierarchy

  Attribute relations → cause, finding, site(anatomy), severity

- Reference Sets (RefSets)

  Groups of SNOMED components to be used for a patricular purpose

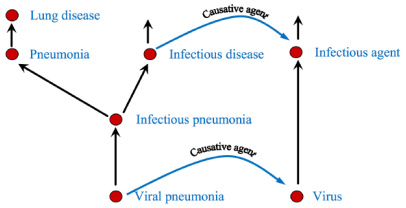

Abbildung 4.2: SNOMED-CT Ontology Structure

LOINC

- Logical Observation Identifiers Namens and Codes
- A universal code system for tests, measurements and obervations
- LOINC is a database with universal codes and names for 71'000 observations identifying laboratory test, clinical measures and survey instruments
- Carries information about each test and measurement
- Represents a measurement, question or observable and consists of

  LOINC Code (Numeric with dash and check-digit)

  LOINC Name (what SNOMED CT would call a term)
- is an international standard → translated into 14 languages
- license for free use

The six Part Types:

- Component or Analyte → What is being measured
- Property → the characteristic of how it is being measured
- time → when the measurement is being completed
- System → Where the analyte originates
- Scale → which way will the test result be expressed
- method → what method was used to make the measurement

example: Sodium:SCnc:Pt:Ser/Plas:Qn

- analyte is Sodium
- measured by substance concetration
- measured at onepoint in time
- measured on either serum or plasma
- result is quantitative
- in this example, method used is not included

ATC Classification System

- Anatomical Therapeutic Chemical (ATC)
- Classification of active ingredients of drugs → according to the organ or system on which they act
- 14 top classes
- controlled by the WHO

Swiss Standards

- AIPS (Arzneimittel-Informations-Publikations-System)
  By Swissmedic
  electronic drug index
- hospINDEX database
  catalog of pharmaceutical products registered in Switzerland
  used by HIS for computerized physician order entry (CPOE)
- DRGs: Diagnosis-Related Groups (Fallgruppen)
  Classication system used for the financing of hospital stays (Fallpauschalenkatalog)
  Basis for reimbursement
  used in hospital for budget planning
  developed in USA (70s)
- SwissDRG is part of the health insurance law reform
  Based on the German G-DRG
  since 2012 with fix rates
    before: financing of daily costs
    after: financing per case by fixed rates
  reduce costs by encouraging hospitals to adopt best practices

4.5.3 Messaging Standards

- Health Level Seven (HL7)
  Interoperability specification for health and medical transaction (HL7 v2, HL7 v3)
  Clinical Document Architecture (CDA), part of HL7 v3
  Continuity of Care Document (CCD): medical summaries as CDA
- Digital Imaging and Communications in Medicine (DICOM)
- Picture Archiving and Communication System (PACS)
- National Council for Prescription Drug Program (NCPDP)
- The INstitute of Electrical and Electronics Engineers 1073 (IEEE1073)
  Medical device communication standard

4.5.4 ICD-10

- **I**nternational **C**lassification of **D**iseases
- Maintened by the World Health organization (WHO)
- ICD-10-CM codes used in documenting diagnoses (cm = clinical modification) published in 1994 → 3-7 characters in length and total about 68'000 diagnoses
- ICD-10-PCS are the procedure codes → 7 characters in length (alphaNum) and total about 87'000 procedures
- Final version of ICD-11 endorsed in 2019 by WHO

Codes in ICD-10

These codes are very specific, which means

- Clinical data with high specificty
- improved care management of beneficariaries
- reliable and robust clinical data that can be used to make intelligent, data driven decision
- more accurate payments
- reduced number of miscoded, rejected and improper reimbursement claims
- better data for fraud and abuse monitoring
- better understanding of healthcare outcomes
- codes to address global dieases emergencies

Kapitel 5

HL7 und HL7 FHIR

5.1 Interoperability

inter: zwischen, opera: arbeit → this happens in different levels

- technical
- syntactically
- semantically
- crossdomain

5.2 The HL7 v2.n Messaging Standard

- Easy to use and understand
- Based on an implicit information model
- also an international use
- Works well withing a single enterprise
- does not work well when sender and receiver are not connected
- available with delimiter or with XML syntax
- Messages initiated by trigger events

5.3 HL7 FHIR STU

- **F**ast → faster to develop, learn, implement
- **H**ealthcare
- **I**nteroperabiliity
- **R**esources → Resources as bricks, web technology (RESTful API)

Kapitel 6

IHE

- IHE is an iniative by healthcare professionals and industry to improve the way computer systems in healthcare share information
- Promotes the cooridnated use of established standards such as DICOM and HL7 to address specific clincal needs in support of optimal patient care
- IHE for
  - Clinicans
  - IT professionals
  - Healthcare Administrators
- IHE is
  - NOT a standardization body
  - NOT a certification body

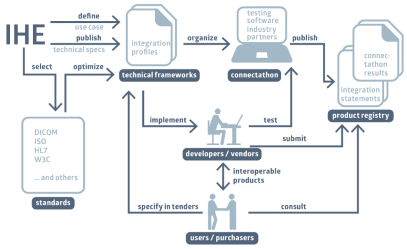

Abbildung 6.1: Descirption IHE

6.0.1 IHE IT Infrastructure

- The IHE IT Infrastructure (ITI) domain addresses the implementation of standards-based interoperability solutions to improve information sharing, workfow and patient care
- started in 2003
- yearly updates defined by
  - planning committee
  - technical committee
- Tested during IHE Connectathons

6.0.2 IHE defines

- Intergration Profile

  Set of Actors and Transaction for specific Use Cases

- Actor

  Information systems or applications that produce, manage or act on information

  Each actor supports a specific set of IHE transactions

  A given information system may support one or more IHE actors

- Transaction

  Transactions are exchanges of information between actors using messages based on established standards

6.0.3 Technical Framework

All document based

- Volume 1: Integration Profiles
- Volume 2a: Transaction ITI-1 to ITI-28
- Volume 2b: Transaction ITI-29 to ITI-64
- Volume 3: Cross-Transactino specifications and content specification
- Volume 4: National Exetensions (but not the swiss ones)

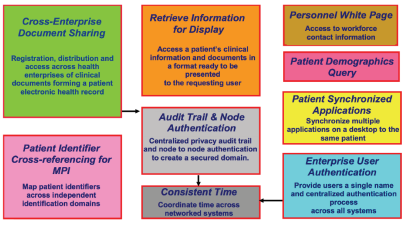

Abbildung 6.2: IHE IT Infrastructure Integration Profiles

6.0.4 IHE Integrations Profiles (Extract)

- Audit Trail and Node Authentication (ATNA)
- Consistent Time (CT)
- Cross-Community Access (XCA)
- Cross-Community Patient Discovery (XCPD)
- Cross

Consistent Time (CT)

It is a timeserver, which provides a base-time. This is very important to make sure every transaction is based on the same time, especially to log all the different transaction (protocol)

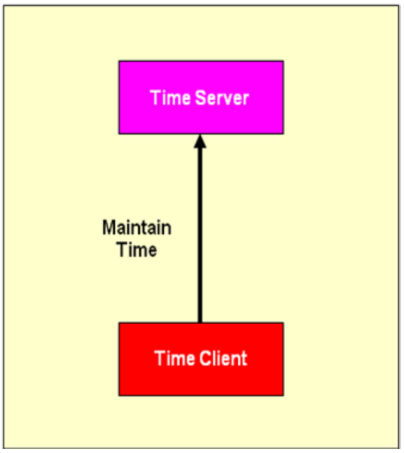

Abbildung 6.3: Workflow from CT

Audit Trail and Node Authentication (ATNA)

How interact every system with eachother and what have the different systems to provide

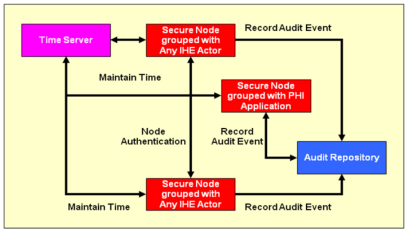

Abbildung 6.4: Workflow from ATNA

Patient Identifier Cross-Referencing

The PIXV3 Profile supports the cross-referencing of patient identifiers from multiple Patient Identifier Domains. These cross-referenced patient identifiers can then be used by 'identity consumer' systems to correlate information about a single patient from sources that 'know' the patient by different identifiers. This allows a clinican to have more complete view of the patient information

Important: Within an EHR it is not allowed to use the 'social security number' (AHV-Nummer). Furthermore there is no national-identify-method for patient. Every hospital has its own ID-System for the patients

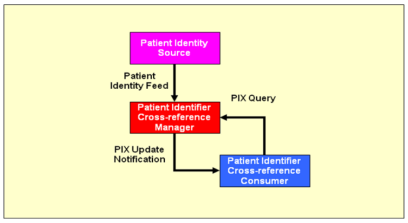

Abbildung 6.5: Workflow from PIX

A **Master Patient Index (MPI)** connects different ID's (e.g. from different hospital) to get one single ID

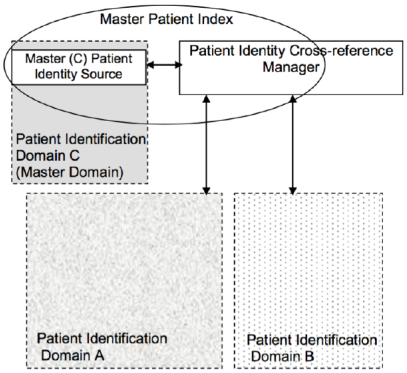

Abbildung 6.6: Workflow from MPI

XDS Cross-Enterprise Document Sharing

- Cross-Enterprise Document Sharing enables a number of healthcare delivery organizations belonging to an XDS Affinity Domain (e.g. a community of care) to cooperate in the care of patient by sharing clinical records in the form of documents as they proceed
- ... tbd ...

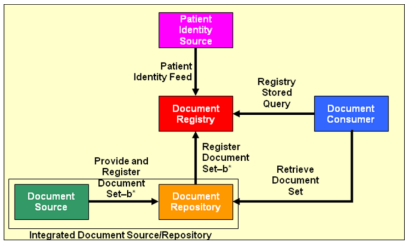

Abbildung 6.7: Workflow from XDS.b

XDS Affinity Domain An XDS Affinity Domain is a group of healthcare enterprises that have agreed to work together using a common set of policies and share a common Infrastructure

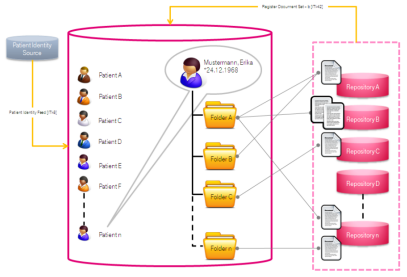

Abbildung 6.8: Workflow to register a document

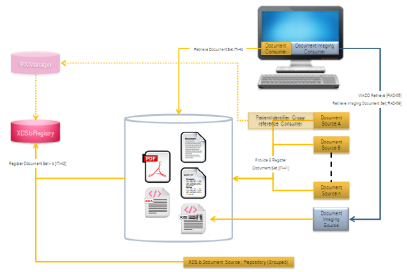

Abbildung 6.9: Workflow for a document-repository

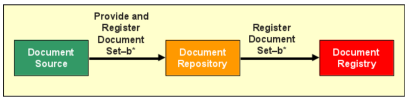

Abbildung 6.10: Workflow from ITI-41

XDS Concepts

- Submission Set

  is related to care event(s) of a single patient provided by the care delivery organization performing the submission request

- Document

  will be stored in the repository

- Metadata

  Data of the submission set and data of the document will be stored in the

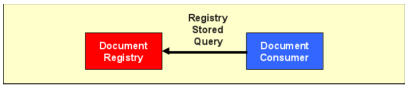

Abbildung 6.11: Workflow from ITI-18

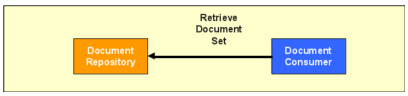

Abbildung 6.12: Workflow from ITI-43

Kapitel 7

EPR

- personal collection of documents relating to your health
- the healthcare professionals file these documets in your EPR
- you alone decied which healthcare professional may read which documents
- you are not obliged to have an EPR. you can choose whether to have an EPR or not
- The Federal Act ont the Electronic Patient Record (EPRA) descripes how the EPR must be organised and technically secured
-

7.1 EPRA

- EPDG / EPRO

  Bundesgesetzt über das elektronische Patientendossier

- EPDV

  Verordnung über das elektronische Patientendossier

- EPDV-EDI (Stufe Department)

  Verordnung des EDI über das elektronische Patientendossier

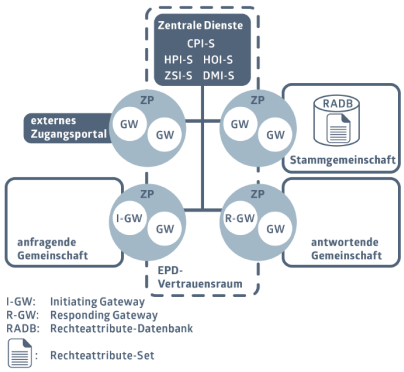

Abbildung 7.1: Schema of EPR

Kapitel 8

Clinical Decision Support

8.1 Decision Support Systems - DSS

- computer-based information system that supports decision-making activities
- can be fully computerized or be part of the human computer interaction
- typically implemented as

  Decision trees

  Rule-based expert systems

  also: 'hard-coded' small, problem-speicific apps

  also: web apps, mobile apps, web-services → non-monolithic

8.1.1 Clincial Decision Making

- medical decision making required the clinician to apply accumulated knowledge to a specific amount of patient information to produce a result that may be a diagnosis, prognosis, cooruse of therapy or the selection of further tests
- ⇒ Too often: the decisions are based on limited knowledge, the information is incomplete or imperfect and the decision must be made during a limited period of time

8.1.2 Challenges of Medical Knowledge

- Knowledge multiplied faster and faster
- to err is human (Irren ist menschlich)
- Knowledge access and decision support at point of care
- Demand for change to increase quality and safety

8.1.3 Decision Supportt today

- Many questions arise during patient care
- If they have questions they consider to

  to ask collegues

  do research in the internet

  use medical guidelines

use medical handbooks

search in bilbiographic retrieval systems (e.g. PubMed)

- ⇒ These tools provde data needed, but they do not help to apply that information

8.2 Usage of CDSS

- passive Usage

  use when advice needed

  get recommendation by CDSS

- active Usage

  gives advice automatically under certain conditions

  user evalute the advice and accept/reject it

  ⇒ alert fatique

8.2.1 Further challanges

Transformation

- from reactive to proactive and preventive care
- from clinical-centric to patient-centered practice
- from training-based interventions to aggregated evidence
- from episodic response to continuous health monitoring

eHealth Opportunities

- Data-driven evidence
- Big Data
- information and knowledge management
- hybrid intelligence → machine and human intelligence

8.3 Clinical Decision Support - CDS

Definition: *A clinical decision support system is any computer program designed to help health professionals make clinical decisions, deal with medical data about patients or with the knowledge of medicine necessary to inerpret such data*
This can be classify into

- tools for knowledge management
- tools for focusing attention
- tools for patient-specific consultation

⇒ CDS systems should identify and reduce the rate of errors, inappropriate actions and adverse events

- reduced medication errors
- decreased costs
- alert and reminders e.g. drug-drug interaction

8.4 Decision Support Systems in Hospitals

Clinical

- Medical Knowledge Management
- Vital Sign Alerts
- Recommendations
- Lab and Medication Checks

Administrative

- Management Cockpits
- Data Mining (BI in Health Care)
- Quality Assurance

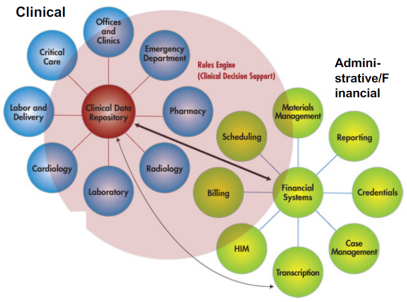

Abbildung 8.1: Decision Support Systems in Hospitals

8.4.1 Basic components

- Medical ontology → standardized vocabulary
- Knowledge Base (KB) → set of rules, condition actions, IF-Then Rules, constraints
- Fact base → working memory, prefilled with data from patient's EHR
- Inference engine → constantly apply rules of KB on working memory, does react on recognized conditions by an action

8.4.2 CDS applications

- alerts and reminders → lab results, medication etc.
- Image recognition and interpretation
- Diagnostic assistance
- therapy critiquing and planning
- clinical guidelines
- condiiton-specfific order sets
- generation of patient data reports

Decision Trees

- basic knowledge representation for logical decisions
- natural order of micro decisions to reach a conclusion

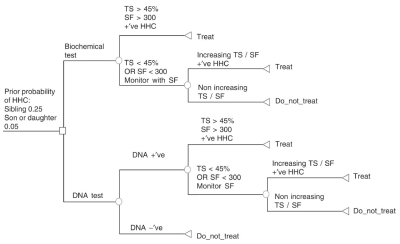

Abbildung 8.2: example decision tree

8.4.3 CDSS for real-time intervention

CDSS as *active knowledge systems* using case-specific patient data are designed to remind the physician

- flag abnormal values
- provide explanation for these abnormals
- alert possible drug interactions or incorrect drug dosages
- recommendation about additional tests and examinations
- advices on treatment

is triggered By

- Task (data entry, data review, workflow) → dose range checks, drug-drug interaction ...
- Event (data-driven) → Monitoring Alerts, Pager alerts on abnormal lab results
- Time (reminders)

8.4.4 The five rights of CDS

CDS intervention should provide

1. the **right information** → evidence based guidance, response to clinical need
2. to the **right person** → entire care team - including the patient
3. through the **right channels** → e.g. EHR, mobile device ...
4. in the **right formats** → e.g. order sets, dashboards ...
5. at **right time** → for key decision or action

8.4.5 Challenge in building a CDSS

Technical

- Complexity of CDSS: Editor, Knowledge Base, Engine
- Knowledge acquisition: espensive to develop and maintain KB
- System integration: workflow, UI

non-technical

- cultural issues and user resistance
- incompatibility among approaches
- Human factors → not matching the five right and alert fatique

8.4.6 CDS Standards

→ HL7 Standards from Health eDecisions (HeD)

- Virtual Medical Record (vMR) data model
- CDS Knowledge Artifact Specification (KAS)
- Decision Support Service (DSS) Spec and IG

aligned with other relevant standards

- vMR: CCD, CCDA, QRDA, Infobutton
- KAS: Order Set DSTU, GELLO, Arden, CDS, Consortium
- DSS: Infobutton, IHE Request for Clincal Guidance

Arden

Syntax

- first approachto knowledge standardization
- Medical Logic Modules (MLMs)

  Each MLM contains maintenance information, links to other sources of knowledge and enough logic to make a signle health decision

  is a stram of text stored in an ASCII file
- MLM are working within host systems

  Input: an input parameter can be committed

  curly brace expressions: dynamic interaction between MLMs and host systems (map values to host system)

  Write Statements: texts can be written to host system

  Output: Commit from MLM after execution of MLM

MLM - Medical Logic Module Composed of slots, grouped into four categories

- Maintenance
- Library
- Knowledge

- Resources

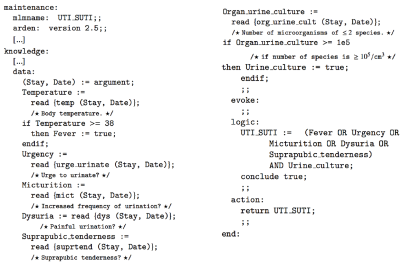

Abbildung 8.3: example MLM

Fuzzy Arden Syntax

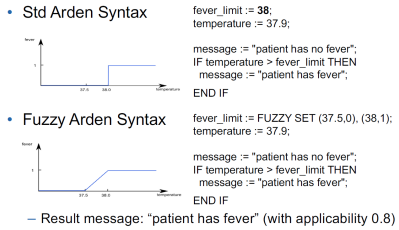

Abbildung 8.4: The Fuzzy Arden Syntax

Guidelines

- Much Development of guidelines since 70s
- Recent efforts aimed at computer-based interpretation

  Goal of delivering patient-specific recommendations at point of care

  Guidelines as core technology for many decision support applications

Guideliens as a core technology

- protocol-based care
- chronic disease management
- consultations
- critical pathways, utilization review (UR) monitoring
- Referral management
- workflow / process optimization
- Infobuttons
- education and training

HL7 CDS Standardization Work

focusing on common Infrastructure

- vMR: an object-oriented virtual medical record subset for decision support
- GALLO: object-oriented query and expression language
- Vocabulary management tools
- Taxonomy of services invoked by rules

Kapitel 9

Medical Imaging Modalities

9.1 Imaging in Clinics

Clinical questions

- Anatomy:
  - Presence and localisation of lesions
  - malformations
  - internal bleedings
  - fluid accumulation
- Physiology / Pathophysiology
  - Energy consumption
  - metabolism
  - drug distribution
  - blood flow

Medical context

- Localisation during surgery
- treatment planning
- screening

Techniques and needed image information

- native tissue contrast (2D grey values)
  - bone fractures (X-ray)
  - soft tissue (CT, MRI, US)
- static images with contrast media , e.g. x-ray (2D) CT angioraphy (2D or 3D), contrast MRI or US
  - enhanced visibility of structures such as vessels
- time-resolved images (4D)
  - cardio-CT
  - organ motions (radiation treatment planning)

- Physiology / Pathophysiology

  time resolved image seriess with contrast media for blood Flow

  visualisation of metabolosim by uptake of radioactive tracers

- treatment planning for radiation therapy

  X-ray absorbtion measurements by CT allows electron density calculation

9.1.1 Radioactive Decay

$$\frac{dN}{dt} = -\lambda N \tag{9.1}$$

Kapitel 10

3D Human Body Visualization

10.1 Application of Medical Visualization

- visual data exploration
- virtual autopsy → patient (in original size) lying on the table to be analyzed
- Multimodel visualization → Overlay of PECT/CT data
- Surgical planning with virtual models
- Using for printing 3D models
- Computer assisted surgery → da-vinci robot
- radiation therapy planning
- medical illustration
- anatomy training
- surgical training

10.2 DICOM Standards

- **D**igital **I**maging **Co**mmunications in **M**edicine
- Covers most image formats for medical application
- specification for messaging and communication between imaging machines

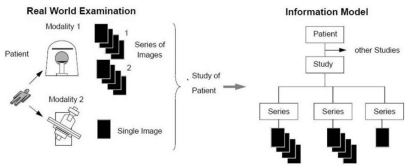

Abbildung 10.1: DICOM Information Model

10.2.1 Modalities

- Radiation (x-rays)
- Computer Tomography (CT)
- Magentic Resonance Imaging (MRI)
- Ultrasound (US)
- Positron Emission Tomography (PET)
- Single Photon Emission Computed Tomography
- Optical

10.2.2 Coordinate Systems

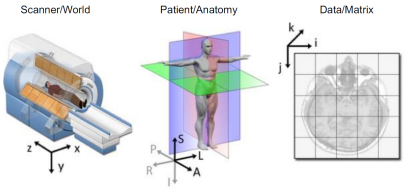

Abbildung 10.2: Coordinate Systems

10.2.3 Orientation

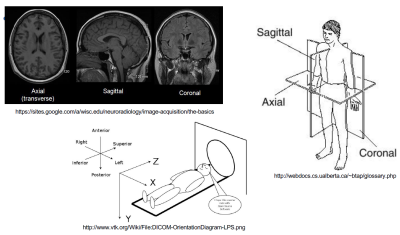

Abbildung 10.3: Orientation

10.2.4 Visualization Modes of Medical Images

1. Extract slices to display 2D image
2. Use transfer function and perform direct volume rendering
3. generate a polygonal model to render surface

Kapitel 11

Introduction to Semantic Web Technologies

To query the data we can use SPARQL - it is really similar to SQL but there is e.g. no join-function.
Baseline for the queries are the graph database model

- easy to interlink and extend
- Data usuallry stored as triples in RDF (Resource Descirption Framework)
- Triple = <subject, predicate, object>

  e.g. «gene X>isExpressedIn<anatomic enitity Y>"

  in SPARQL → Select * where {?gene isExpressedIn ?anatEntity}
- tto: tutorial object
- ttr: tutorial resource

11.1 Semantic Web Technology Stack

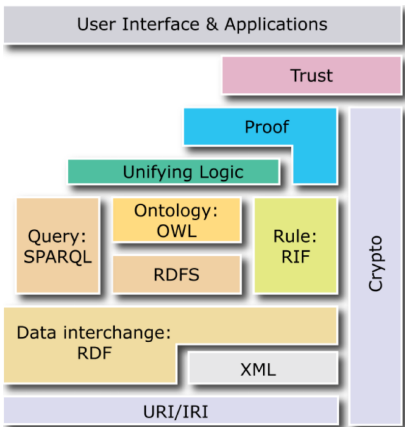

Abbildung 11.1: Semantic Web Technology Stack

11.1.1 Ontology

What is an ontology?

- a model of a domain
- A vocabulary consisting of classes and properties

- Machine-readable knowledge representation

How do we build one?

- Descripe new classes and properties
- Extend existing ontologies (RDF schemas, dbpedia, ...)

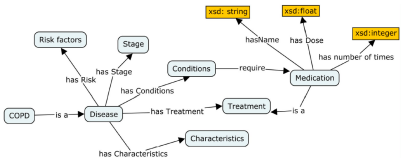

Abbildung 11.2: Simple Ontology

Why data integration?

- Study diseases across species

  e.g. using model organisms (mice) to understand / predict evolution of disease in humans

- Repurpose drugs

  Prioritise existing drugs for new diseases $\leftrightarrow$ reducing time and cost for devel

- Understand gene function

  E.G. what genes have a role in respiration?

  What genes are associated with possible cancer types?

It is very important to build precise queries. For example the term 'rich' can be interpreted differently. e.g. Bill Gates has another understanding in rich, so it won't be a good idea to set the question 'which employees are rich?'

Kapitel 12

mobile Health

eHealth + mobile = mobile health = mHealth

12.1 Telemedicine

Telemedice provides clinical health care from a distance using ICT, this includes:

- Telehealth / Teleconsultation (via teleconferencing)
  Phone and Video Conferencing
- mobile health
  Smartphones, smartwachtes, wearables
- Remote monitoring
- Outsourced speciality care as digital services
  Tele-cardiology, -psychiatry, -dentristry, ...
  Integrated via digital networks

12.1.1 in Practice: Medgate AG

- leading provider of integrated healthcare services in Switzerland
- Up to 6000 teleconsultations a day
- Up to 2.5 million patient records
- Teleconsultation
  Communication channels: telephone, internet, video, App
- Telediagnostics
  diagnosis of images
  telemonitoring
- Teletherapy
  prescirption of drugs
  sick leave certificates
- Medgate App

12.2 mHealth Expactations

→ Healthcare is everywhere

- smartphone is part of our life

  Smartphones are always on, computers are not

- eHealth at any point of care

  at home / work / bedside etc.

- telemedicine services

  Remote health serices in rural regions

  health services for developing countries

- Patient engagement

  increased self-management of well-being and illness

  reduced number of hospital stays

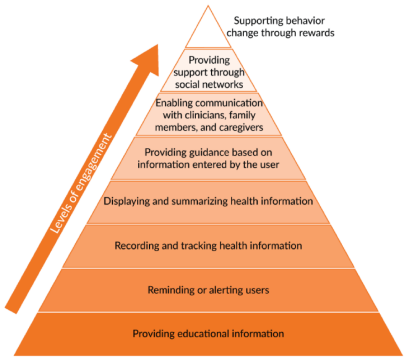

Abbildung 12.1: Patient Engangement using Apps

12.2.1 Types of mHealth Apps

- Clinical assistance apps
- Reference / database apps (eg.UpToDate)
- General facility information / communication apps
- Monitoring apps (telemedicine)
- Reminder apps (e.g., medication)
- healthy life apps (fitness, nutrition, diets, mood)
- patient portal / EHR apps
- speciality / disease-specific apps (pregnancy, kids, diabetes)

⇒ most apps re for patients / consumers, not for healthcare professionals

12.3 mHealth today

- Large number of lifestyle, fitness and well-being apps
  no clear evidence on their quality and reliability
- Role of mHealth in healthcare systems unclear
  Personal vs. clinical mHealth apps, business models
- Issues on privacy and security
  a lot of free Apps
  Regulations and laws are not (yet) established
- Standards, protocols and guidelines are evolving
  importance of sharing and transfering best practices
  need for certification schemes / quality labelling

12.3.1 mHealth Challenges

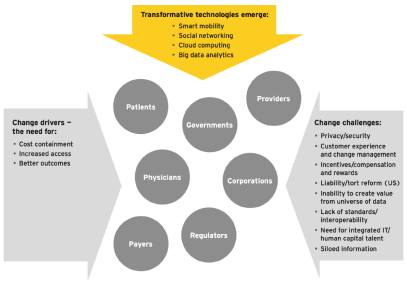

Abbildung 12.2: eHealth and mHealth Challenges today

12.3.2 eHealth App Regulation

- International regulations
  US: FDA, Health Insurance Portability and ACcountability Act (HIPAA) Security Rule
  EU: Medical Device Regulation (MDR)
- National regulations in CH
  Datenschutzgesetz (DSG), Datenschutzverordnung
  Heilmittelgesetzt (HMG), Medizinprodukteverordnung (MepV) → Anlehnung an EU-Richtlinien
- Guidelines
  App Store Review Guidelines
- Recommendations

⇒ *Is an eHealth App a Medical Device?*

EU MEDDEV regulations

- Hospital Information Systems are not qualified as medical devices. However they may be used with additional modules which might be qualified in their own right as medical devices
- EHR systems that simply replaces a patient's paper file does not meet the definition of a medical device. But certain modules can be a medical device
- Modules that contribute to diagnosis, therapy and follow-up (e.g. generate alarms) are qualified as medical devices
- Decision Support Software are qualified as medical devices

Apple App Store Guidelines

⇒ Strict rules for health and wellness apps

- privacy protection
- avoid physical harm

  Inaccurate data that could potentially cause physical harm

  Apps related to forbidden drugs

  Apps with harmful recommendations
- Drug dosage calculators must come from the drug manufacturer, a hospital, university, health insurance company, or other approved entity, or receive approval by the FDA or one of its international counterparts

What does this mean?

- Laws and reulgations are currently work in progress
- If a software is a medical product / medical device

  I) A CE certification is need

  II) The software company has to run a documented software quality management process (eg. ISO 13485)
- App store might reject your app

12.4 Sustainable eHealth Apps

- Legal and ethical
- Financial
- Clinical
- Technological
- Integrated
- Personalized

12.5 mHealth App Functionalities

- Data capture
- Data Analysis
- Sense making
- Data sharing

12.6 Patient Generated Data

- Behavioral characteristic

  Self-monitored vital data

  physical activity

  eating patterns / risky drinking

  medication taking

  sleep quality

- Psycho-social characteristic

  Mood and stress

  anxiety and depression

  quality of life symptoms (Pain free, headaches, migraine etc.)

Kapitel 13

mHealth Wearables

13.1 Health Devices at Home

There are two main topics

- Smart Homes
  - Digital weighing Scale
  - Air quality sensors
- Ambient-Assisted Living (AAL)
  - automated wireless and fixed monitoring and assistance to help people cope with age-related limitations
  - speech-recognition devices
  - cameras
  - floor sensors
  - smart furnitures
  - urine monitors

13.1.1 AAL

Assisted Living + Ambient Intelligence → Assisted living technologies for older adults. This is possible through different field in Technologies:

- Smart homes
- mobile devices
- wearable sensors
- smart fabrics
- assistive robotics

→ Sensors and actuators integrated into everyday objects

Health Monitoring and Smart Homes

- Ambient
  - Room temperature
  - air quality
  - weather condition

air pollution

pollen concentration in the air

- Surveillance

  movement

  behaviour

Kapitel 14

Glossary

has to be done Fachbegriffe PIS CIS HIS EHR etc...

- CDS - Clincial Decision Support
- DSS - Decision Support Systems
- CDSS - Clinical Decision Support Systems
- Computerized Clinical Decision Support
- Medical Decision Support
- MDSS - Medical Decision Support Systems
- CPOE - Computerized Provider Order Entry
- DRC - Dose range checks
- DDI - Drug-drug interaction
- HeD - Health eDecisions
- vMR - virtual medical Record
- KAS - Knowledge Artifact Specification
- MLM - Medical Logic Modules
- AAL - Ambient Assisted Living