Computer-Aided Decision Support Systems (CDSS)

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- Philippe Massari = Medical Informatician, retired, 25 experience in medicine (cardiology & reanimation), SIBM
- Nicolas Griffon = Medical Informatician, SIBM

- **Main fields of research**
  - CDSS (former field in the ’80s and ‘90s)
  - Knowledge engineering
  - Terminologies and ontologies, semantic web
  - Information retrieval & automatic indexing

SIBM in 2015

Department of BioMedical Informatics

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Joanne PACHECO (Resident GP)				
Jean-Philippe LEROY (PH 1/2 FT)		**Grant Hospital**	**Grant Regional Council**	Grant Research projects

CDSS: definitions

MeSH definitions… and its limits

- **Decision support systems, clinical (n=9,089)**
- Computer-based information systems used to integrate clinical and patient information and provide support for decision-making in patient care.
- **Decision making, computer-assisted (n=100,899)**
- Use of an interactive computer system designed to assist the physician or other health professional in choosing between certain relationships or variables for the purpose of making a diagnostic or therapeutic decision.
- Not located in the same tree **(n=108,297) AND ISRAEL (n=1,016) (France 3,567)**
  - As a terminologist, **Decision support systems, clinical IS A Decision making, computer-assisted**
- To learn more:
  - Clinical Decision Support Systems. MA Musen, B Middleton, RA Greenes. In: Biomedical Informatics (EH. Shortliffe, JJ. Cimino, Eds), Springer, 2014.
  - Systèmes d'aide à la décision en médecine. Rapport à la Haute Autorité de Santé (2010).

Results

- MeSH (22)
  - MeSH Descriptor (22)
    - → Cardiac-Gated Single-Photon emission Computer-Assisted tomography
    - → computer-aided design
    - → computer-assisted instruction
    - → Cone-Beam computed tomography
    - → **decision making, computer-assisted**
    - → diagnosis, computer-assisted
    - → drug therapy, Computer-Assisted
    - → image interpretation, Computer-Assisted
    - → image processing, Computer-Assisted
    - → imaging, Three-Dimensional
    - → numerical analysis, computer-assisted
    - → radiographic image interpretation, Computer-Assisted
    - → radiotherapy planning, Computer-Assisted
    - → radiotherapy, Computer-Assisted
    - → signal processing, computer-assisted
    - → spiral Cone-Beam computed tomography
    - → surgery, computer-assisted
    - → therapy, Computer-Assisted
    - → tomography, emission-computed
    - → tomography, emission-computed, single-photon

Description | Hierarchies | Relations | PubMed / Doc'CISMeF

Decision making, computer-assisted (MeSH Descriptor)

Full tree

- MeSH top tree
  - Information Science Category
    - information science
      - medical informatics
        - medical informatics applications
          - **decision making, computer-assisted**
            - diagnosis, computer-assisted
              - image interpretation, Computer-Assisted
                - radiographic image interpretation, Computer-Assisted
            - therapy, Computer-Assisted
              - drug therapy, Computer-Assisted
              - radiotherapy, Computer-Assisted
                - radiotherapy planning, Computer-Assisted
                - radiotherapy, conformal
                - radiotherapy, intensity-modulated
              - surgery, computer-assisted

HeTOP

decision clinical

examples: asthme, asthma, D001249.nu, asth,

1 matches in 0,25 s ★★★

Terminologies selection

Your queries (8)

Views history (23)

Results

- MeSH (1)
  - MeSH Descriptor (1)
    - decision support systems, clinical

Description | Hierarchies | Relations | PubMed / Doc'CISMeF

Decision support systems, clinical (MeSH Descriptor)

Full tree

- MeSH top tree
  - Information Science Category
    - information science
      - medical informatics
        - medical informatics applications
          - information systems
            - **decision support systems, clinical**

Decision in medicine… and health

- The goal of medicine in 2015 is to obtain the best strategy, which leads to the maximum benefit for the patient (and the population), whereas the risks and the costs should be minimized

- Two main steps in the medical decision
  - Decision about diagnosis
  - Decision about therapy

- In the process of care, several (minor) types of decision may occur (e.g. procedure, imaging, lab tests)

Decision in medicine … and health

- How a physician (or HP) is taking a decision?
  - Complex processus, which needs reasoning, based on facts and confronting to knowledge

- Before CDSS, it is necessary to study this complex processus to perform an adequate decision in medicine (and health)

Basis of a decision

- Facts
  - All the facts that can be retrieved from patient interview, the examination, lab tests, imaging, procedures…
  - Clinical skills
- Knowledge
  - Most up-to-date knowledge,
    - in the memory of the HP
    - In a (electronic) book or Web site
  - More and more knowledge are integrated into clinical guidelines
  - Computer-aided (assisted) access to guidelines or computerized guidelines (contextual knowledge
  - Two Israeli teams in this area
    - Yuval Shahar (Ben Gurion University, Beer Sheva)
    - Mor Peleg (Haifa University)

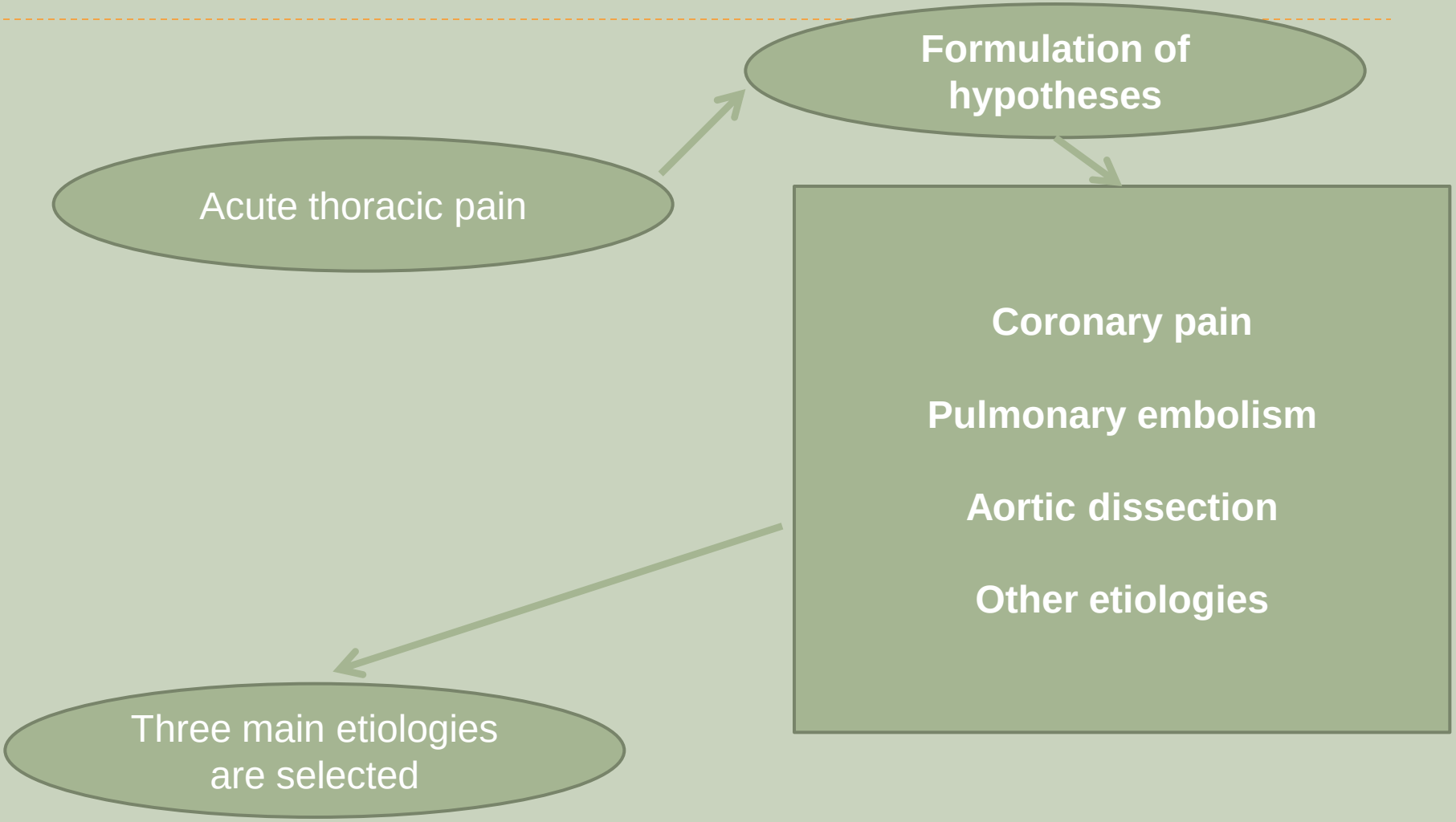
Methods of reasoning

- Several methods of reasoning exist:
  - Deduction
  - Abduction
  - Induction
  - Causal
- These methods may be combined in a global process =>

Hypotheses & deducing, which is the most used process in medical diagnosis

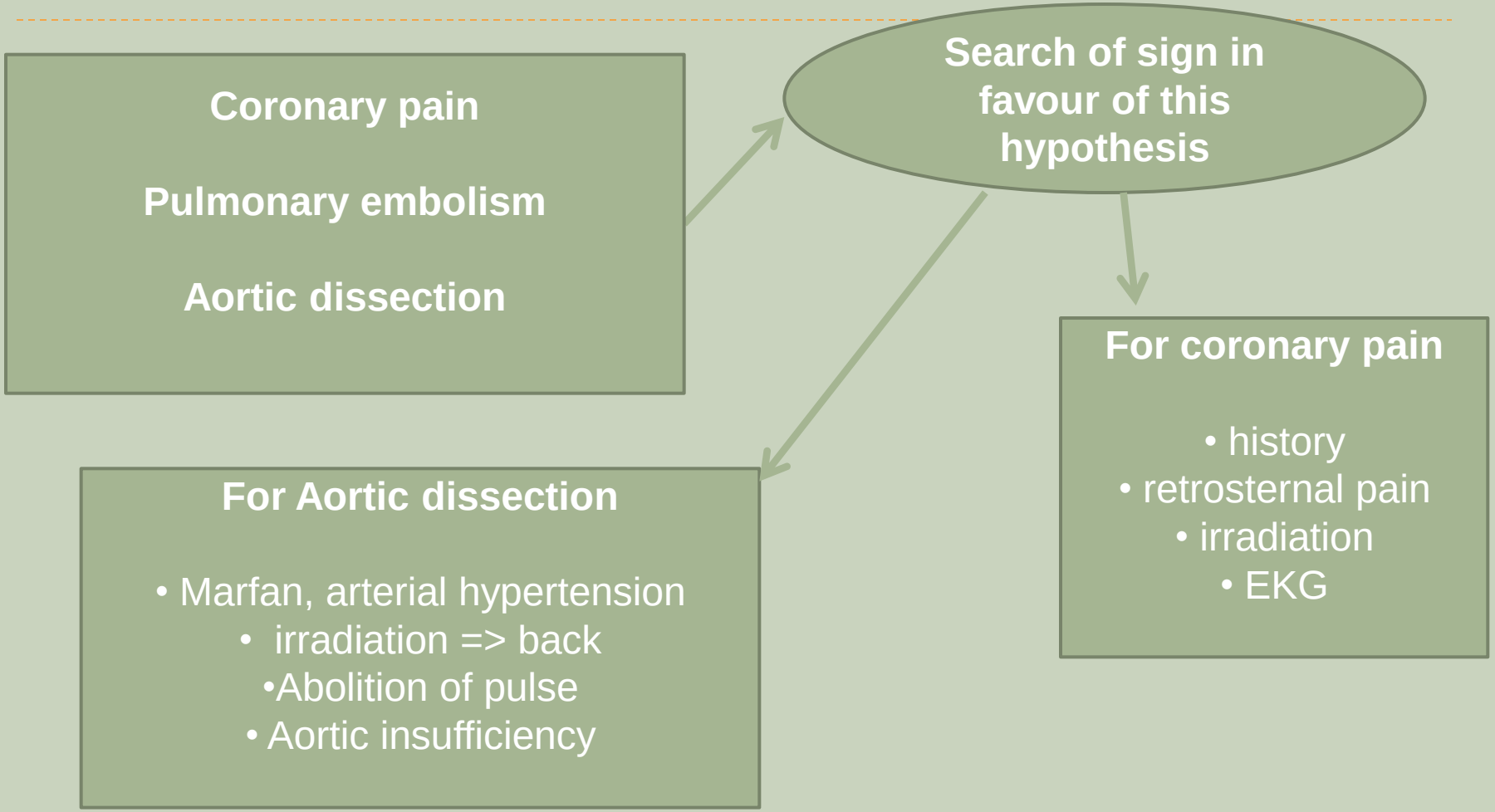
Hypotheses & deducing reasoning

Formulation of hypotheses



Hypotheses & deducing reasoning

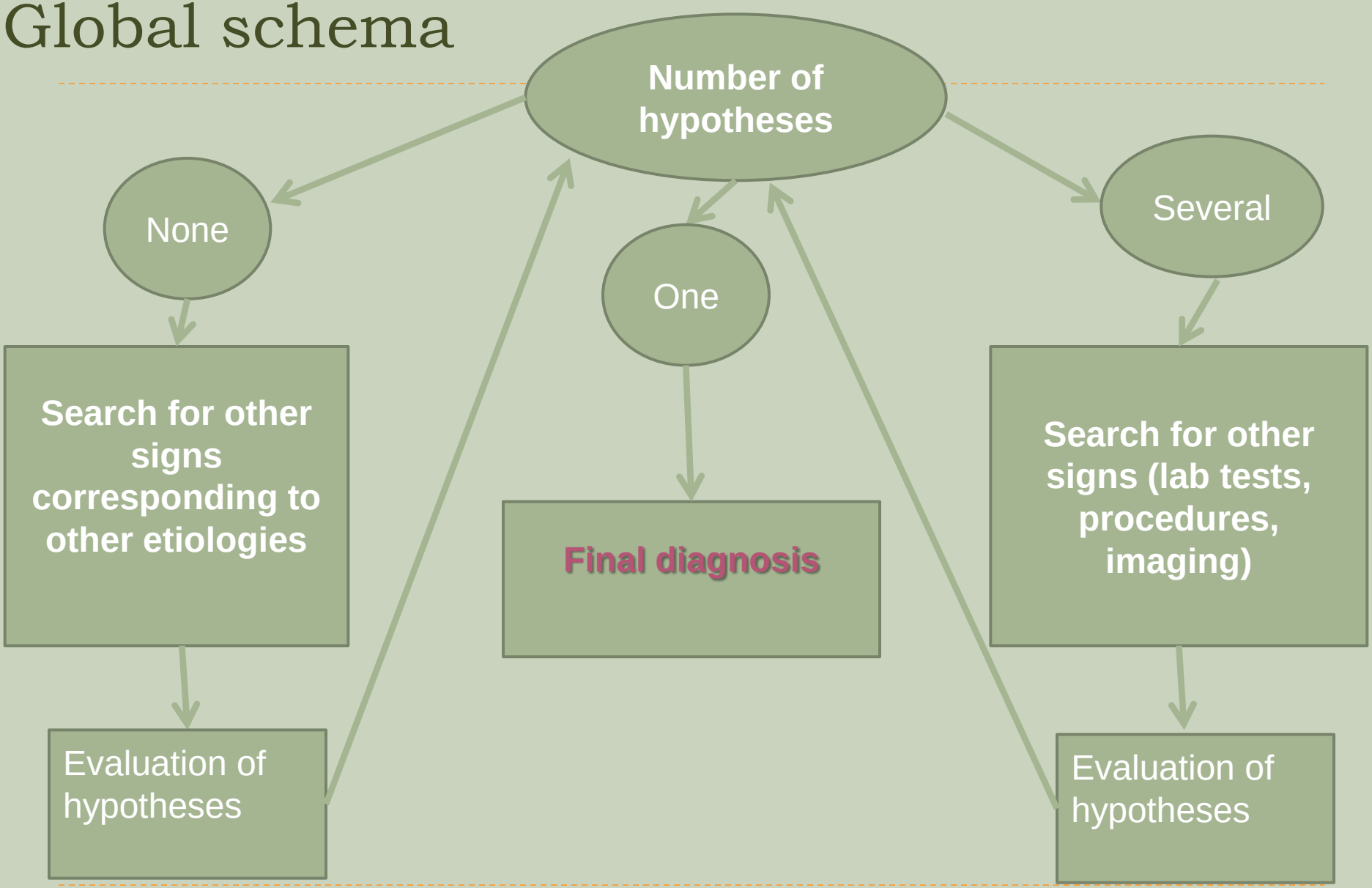
Evaluation of hypotheses



Evaluation of hypotheses

Hypotheses & deducing reasoning

Global schema



Computer-aided decision

- All the phases of a medical decision could be computer-assisted
  - Gathering data, using interactive actions
  - Access to knowledge bases (information bases)
    - Drug databases, genetic databases
    - Terminologies and ontologies => teaching +++
    - Computerized guidelines, InfoButtons, documentary databases?
  - Every step of the decision process, including reasoning +++

Computer-aided decision

- Decision process
- Objective: to allow the physician to take care of the patient with the CDSS to the best of the patient, minimizing the risk (first, do not harm)
- Several types of CDSS
  - Algorithm (computerized guidelines)
  - Expert systems
  - Probabilistic systems
  - Neural network (black box)

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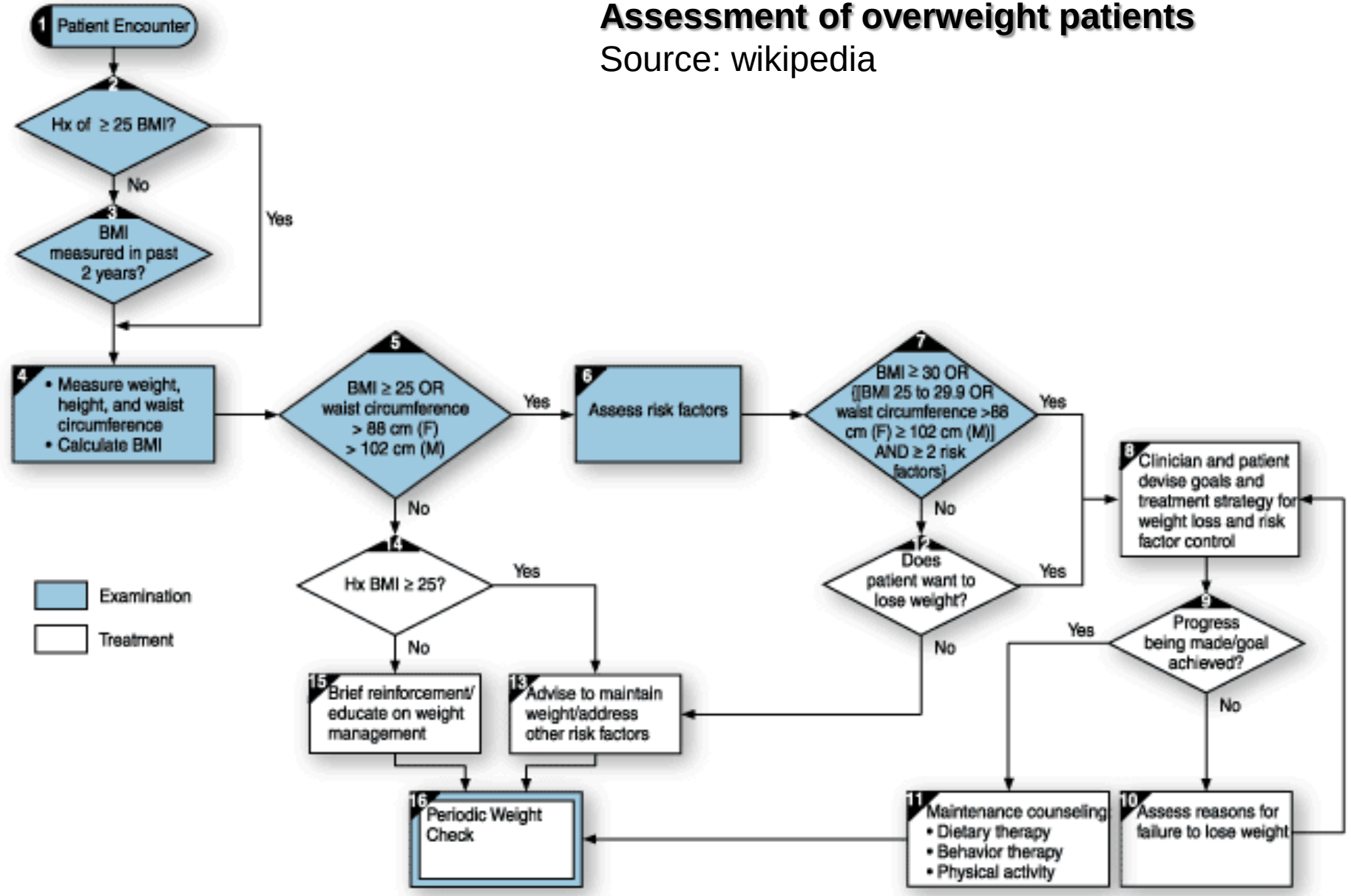
Algorithm

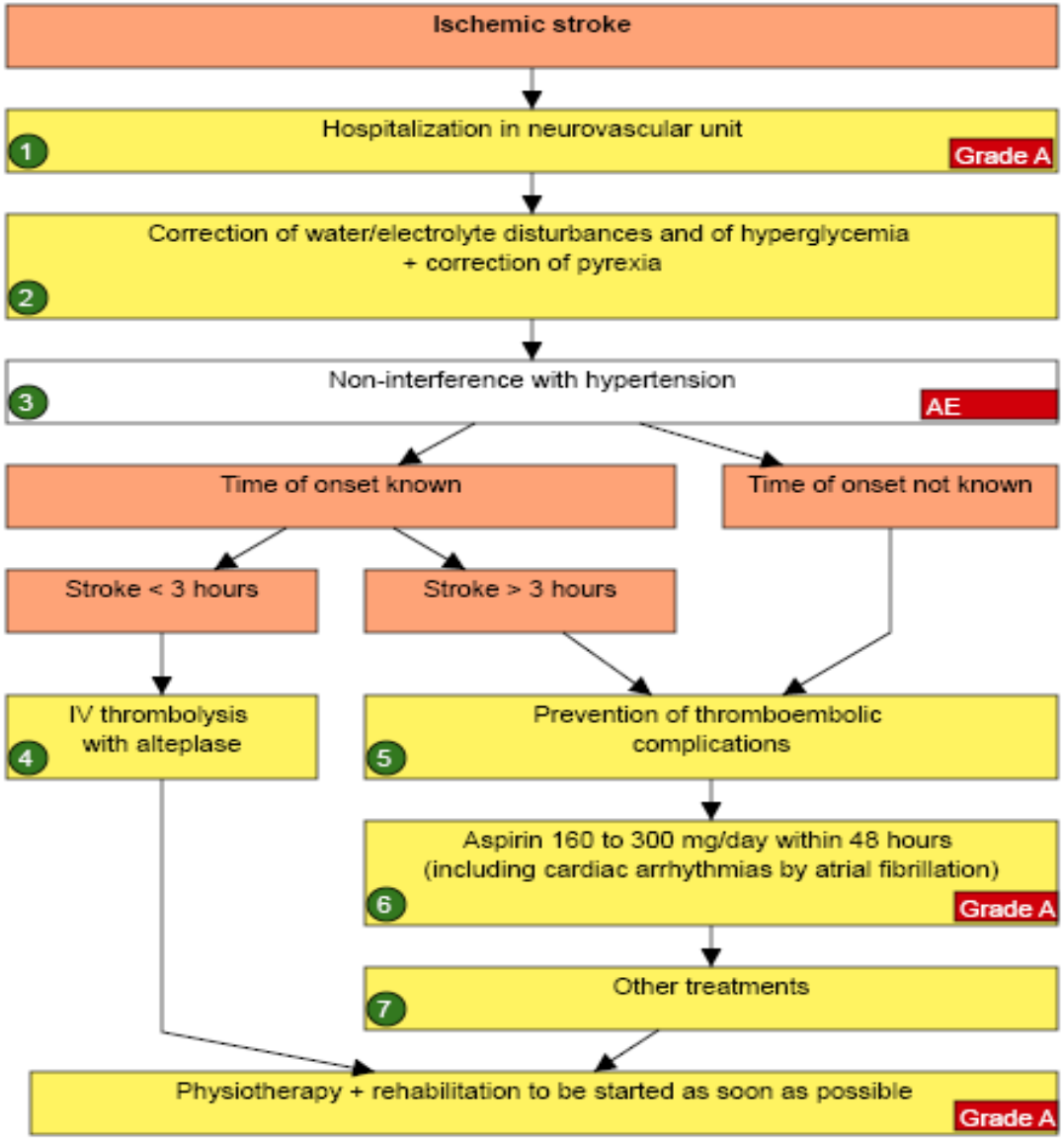
- Simplest method but really easy to understand for a MD
- Nodes (questions or decisions) & arcs
- Tree or graph
- Decision tree (theory of decision)
  - Ponderation of each node
- Vidal Recos
  - 175 algorithms for GPs
  - Paper book: quite a success (n>50,000)
  - Electronic book integrated into Vidal suite (including a drug database)

Assessment of overweight patients

Source: wikipedia



* This algorithm applies only to the assessment for overweight and obesity and subsequent decisions based on that assessment. It does not include any initial overall assessment for cardiovascular risk factors or diseases that are indicated.



Ischemic stroke
Vidal Recos **2005**

Mainteance of CDSS +++

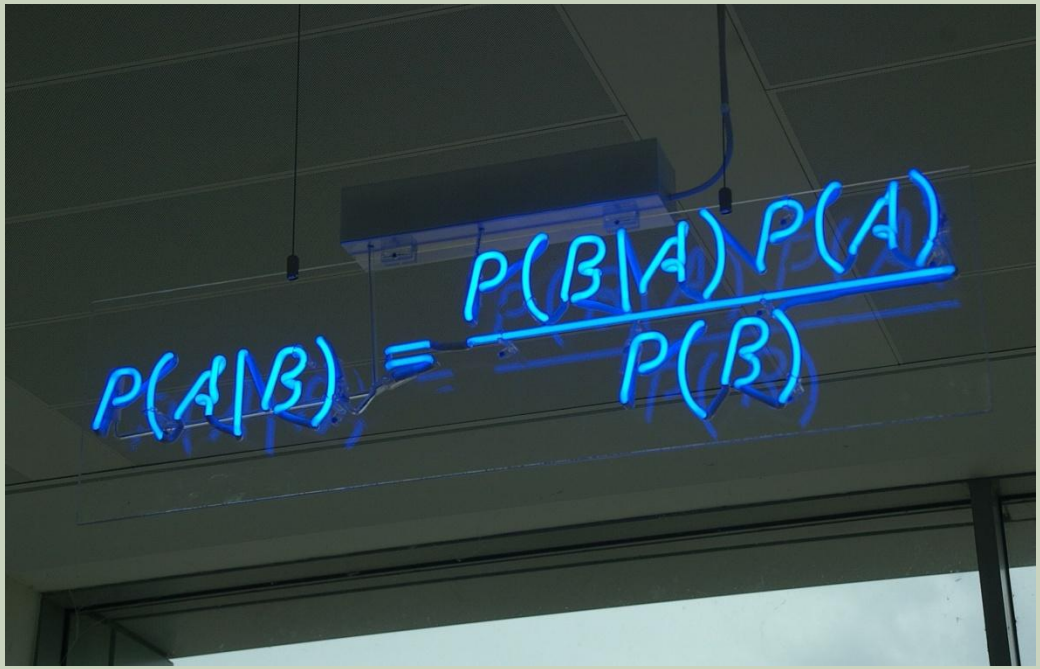
½ life in medicine = 7 years

PhD in SIBM (A. Merabti)
Automatic detection of knolwedge modification among tow guidelines on the same subject

Bayes theorem

Conditional probabilities

P(A/B) difficult to compute



More easy to compute p(B/A)

Each hypothesis has a probabiilty, which evolve according to the presence or absence of a sign (or a procedure)

Stop if a threshold is obtained

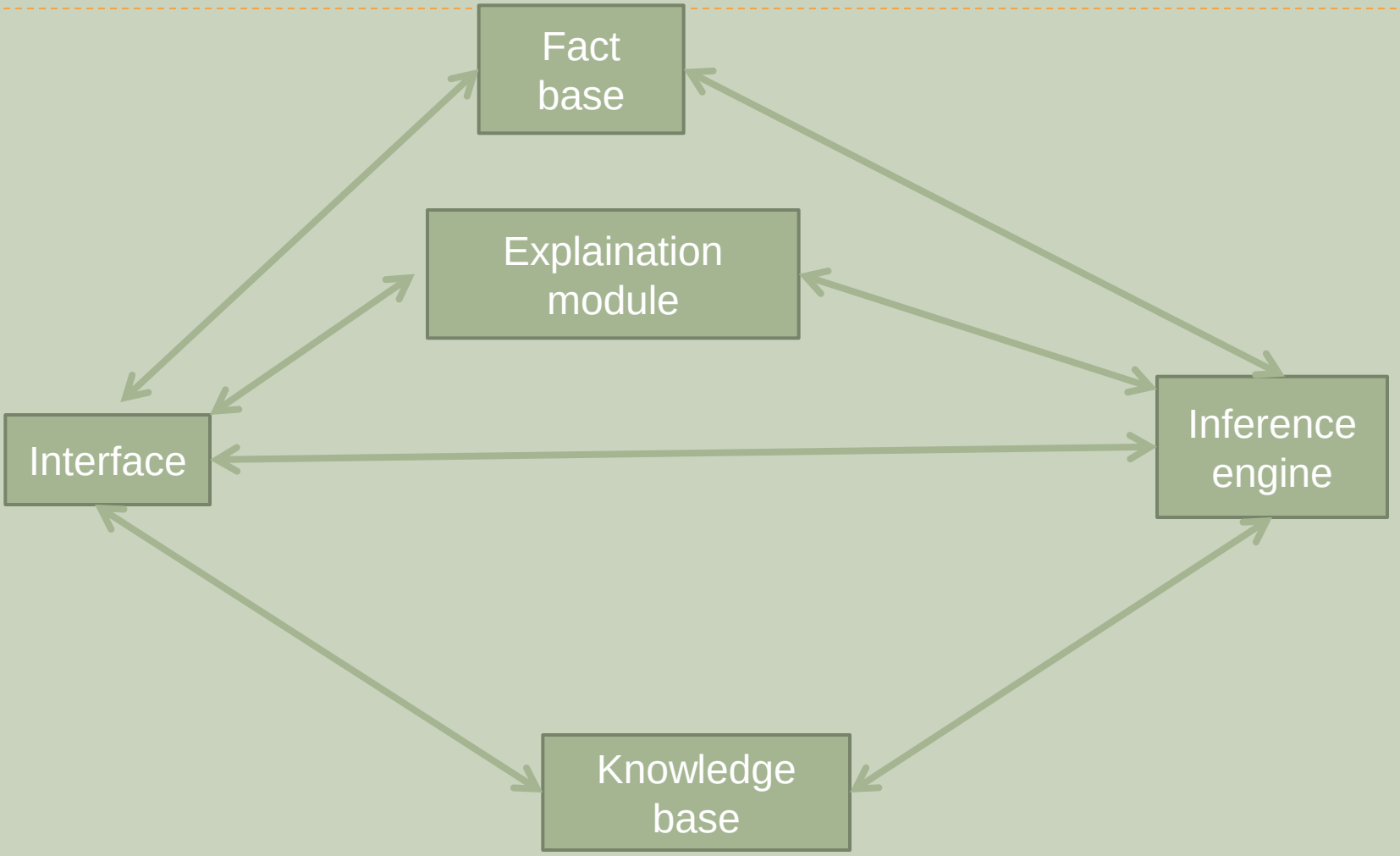
Population database necessary+++

One of the most famous CDSS in the history
De Dombal et coll. Human and computer-aided diagnosis of abdominal pain: further report with emphasis on performance of clinicians. BMJ **1974**
Leeds on ‘acute’ abdomen
As efficient as the senior surgeon
Much less efficient outside Leeds

Expert systems

- Main idea is to dissociate knolwedge and computerization (inference engine)
- Mimicking the process of human expert
- From production rules, ES are able to process the reasoning
- Production rules
  - If A and B then C
  - If thoracic pain and troponin then diagnosis = myocardial infarction
  - Introduction of a likelihood coefficient
    - If A and B then C (x), with x $\in$[0, 1]
    - If staph. Infection and hospital then staph. Methy resistant (0.8)
    - If staph. Infection and non hospital then staph. Methy resistant (-0.4)
  - Order 0, 0+ (temperature >38), 1 (f(x), generalization to one drug class)

Expert systems



Expert systems

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- Production rules
  - If A and B then C
  - If thoracic pain and troponin ⇧
    then diagnosis = myocardial infarction
  - If betablockers then… (explosion of the concept ‘betablockers’ to all the drugs of this therapeutic class)
- Mycin (most famous ES in medicine)
- Internist (all the knowledge of internal medicine)

Alerte fatigue +++

- Very important phenomena when HP use CDSS
- Too many alerts => stop using the CDSS
- Very well documented with drug databases (testing the drug interactions using CPOE)
  - Four levels of drug interactions
  - Only the two more serious activate an alert
    - Could be sometimes dangerous

CDSS evaluation

- Inspired by clinical trial
- Four phases
  - Phase I: validation in silico (in the lab); coherence of the knowledge
  - Phase II: evaluation in vitro (in the lab), including
    - GUI evaluation (ergonomy, +/- qualitative evaluation)
    - Feasability study: quantitative evaluation on a small sample
  - Phase III: formal evaluation
    - Randomized trial (a group with CDSS and a group without CDSS)
    - E.g. in France, current trial with/without DP in three medical specialties
  - Phase IV: post-marketing;
    - iterative evaluation over time (testing the maintenance of the CDSS)
    - evaluation outside the place of development (testing the portability)

CDSS evaluation: based on systematic reviews

CDSS are a way to overall improve healthcare

- ≈ 2/3 of published studies, use of CDSS led to an improve of healthcare
  - o Prescription are in phase with clinical guidelines (66/100 studies – systematic review of Garg in 2005
  - o Reducing the relative risk of prescription errors (8/10 studies – systematic review of Ammenwerth in 2008
  - o Reducing the relative risk by more than half of potential drug side effects when using CPOE (14/25 studies – systematic review of Ammenwerth in 2008)
- in the other cases, no improvment or worse => e-vigilance (FDA)

FIRST DO NOT HARM

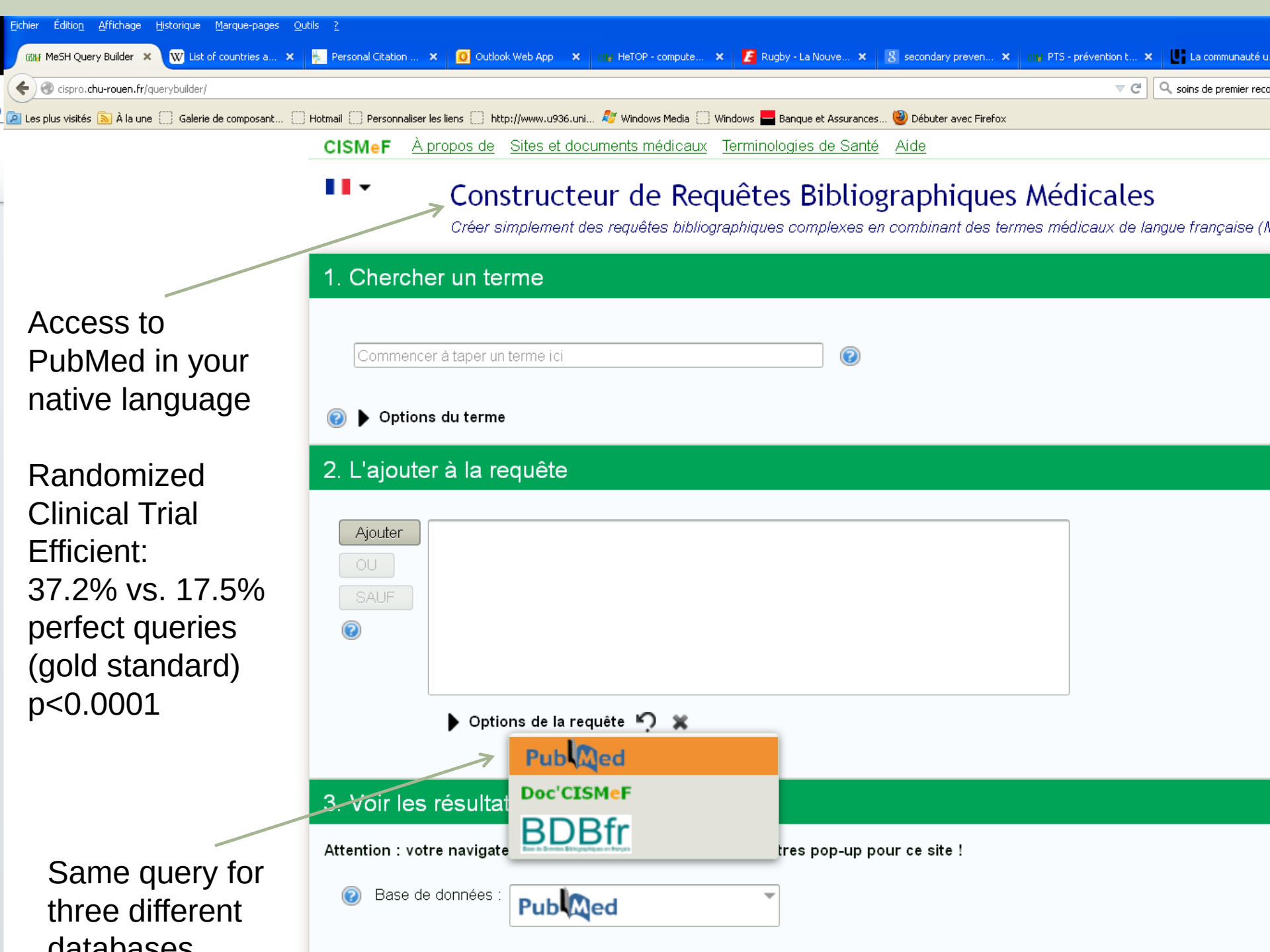
- Certification of CDSS +++ clinical information systems => CMIO (new job opportunity)
- Mean amplitude of improving are still relatively modest (systematic review of Shojania in 2010);

Significan clinical improvment :

- o 5 to 10% in ≈ 1/3 of the 28 studies ,
- o >10% in ≈ ¼ of these studies

Fuzzy limits: CDSS?

- Documentary Information Systems
  - PubMed alone **+/-**
  - CRBM: access to PubMed in Franch, automatic translation: **yes**
- InfoButton
  - Defined by JJ. Cimino (US)
  - Accessed to contextual knowledge
- CPOE
  - Yes, when testing drug interactions

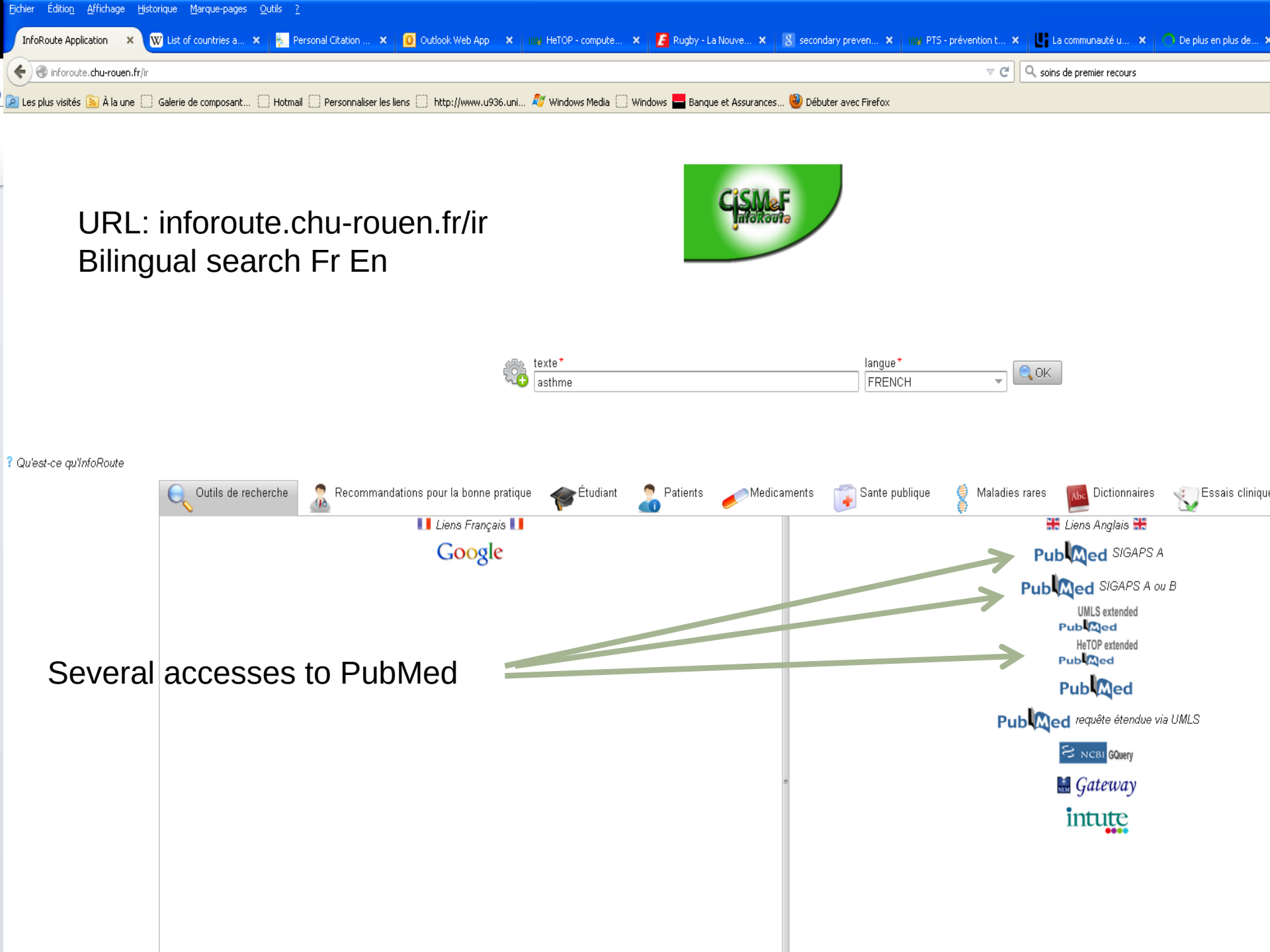


Access to PubMed in your native language

Randomized Clinical Trial Efficient:
37.2% vs. 17.5% perfect queries (gold standard)
p<0.0001

Same query for three different databases

URL: inforoute.chu-rouen.fr/ir
Bilingual search Fr En



Several accesses to PubMed

CDSS: not a big success overall

- Thousands of CDSS developped in the last 40 years
- Few were properly evaluated (randomized trial)
- Less in real use
- When in use in few institutions in the US
  - More CDSS are implemented, more the results are positive
  - Postive feedback
  - Integration of CDSS into health (hospital) information systems

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CDSS: main key factors of success

- Well adapted to work process
- Standard forms to knowledge engineering used by CDSS
- Integration of CDSS into health (hospital) information systems
  - Avoid double entry; avoiding double interface to manage
  - MD staying in his/her software
- Automatic triggering of CDSS, without interfering with the MDs => avoiding alert fatigue
- Providing the right information (knowledge) to the right person at the right time

CDSS: main key factors of success

- For computerized guidelines
  - Display an action and not an observation
    action: reduce the prescription of drug X by Y mg because of creatinin clearance
    observation: the creatinine clearance is diminished
  - Execute the proposed guidelines in your own EHR
    - Formalization of guidelines (RDF/XML)
    - UK NHS Quality Outcomes Framework for GPs
    - Clinical Decision Support Initiative, US AHRQ
    - In France, HAS (equivalent to US AHRQ) << Vidal (private company)

Clinical Decision Support Consortium

- Partners Healthcare (Boston)
- Department of Biomedical Informatics (Regenstrieff Institute, Veterans Health Administration, Kaiser Permanente)
- Private companies (Siemens, GE Healthcare, NextGen)
- Objectives
  - State of the art
  - Develop a model and methods to translate the knowledge included in guidelines to create efficient CDSS
  - Build KBs at the US federal level to be reused
  - Evaluate and disseminate

GLIDES

- **GuideLines Into DEcision Support**
- Yale University + Nemours Foundation
- Objectives
  - Develop computerized guidelines about chronic diseases and primary prevention
  - Evaluate on GE Healthcare & EPIC Systems

CDSS: and now?

- National initiatives to promote CDSS
  - In Europe, besides UK and nordic countries, few countries are using CDSS
- Three main obstacles:
  - Resistance of end-users
    - Not enough integrated in the daily practice
    - Loss of time
  - Complexity and costs of CDSS KBS; huge difficulties to reuse it and to share it (maintenance +++)
    - Semantic interoperability
- Relative consensus to promote CDSS in OECD countries
  - Security, confidentiality, vigilance of CDSS
  - Certification of clinical information systems; rewarding good practice; pay for reporting; already existing in the US (FDA)

Future of CDSS?

- Integration of CDSS into health (hospital) information systems
  - Already a fact in four main institutions in the US
- Apps
  - Calculation of several paramters (BMI)
  - Internet of things
    - Integration of Internet of things into health (hospital) information systems => semantic interoperability