What is Computable Knowledge, and why does it matter ?

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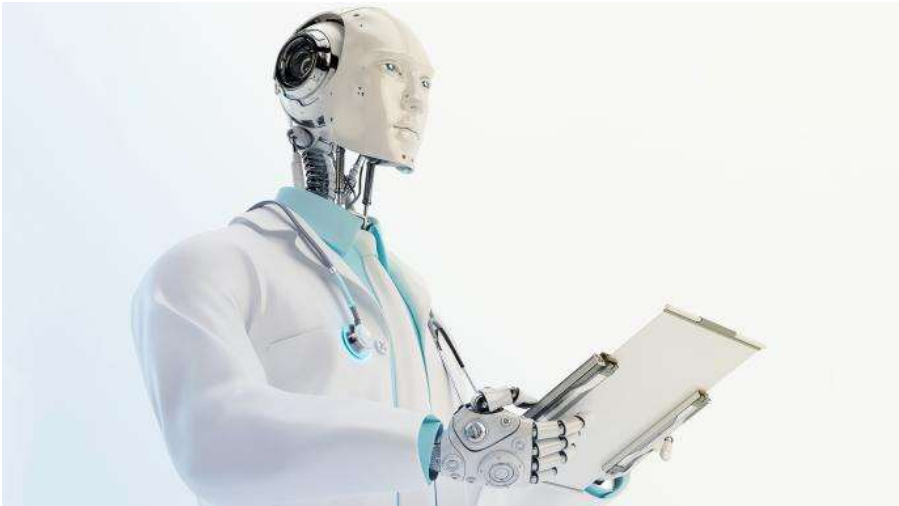


Agenda

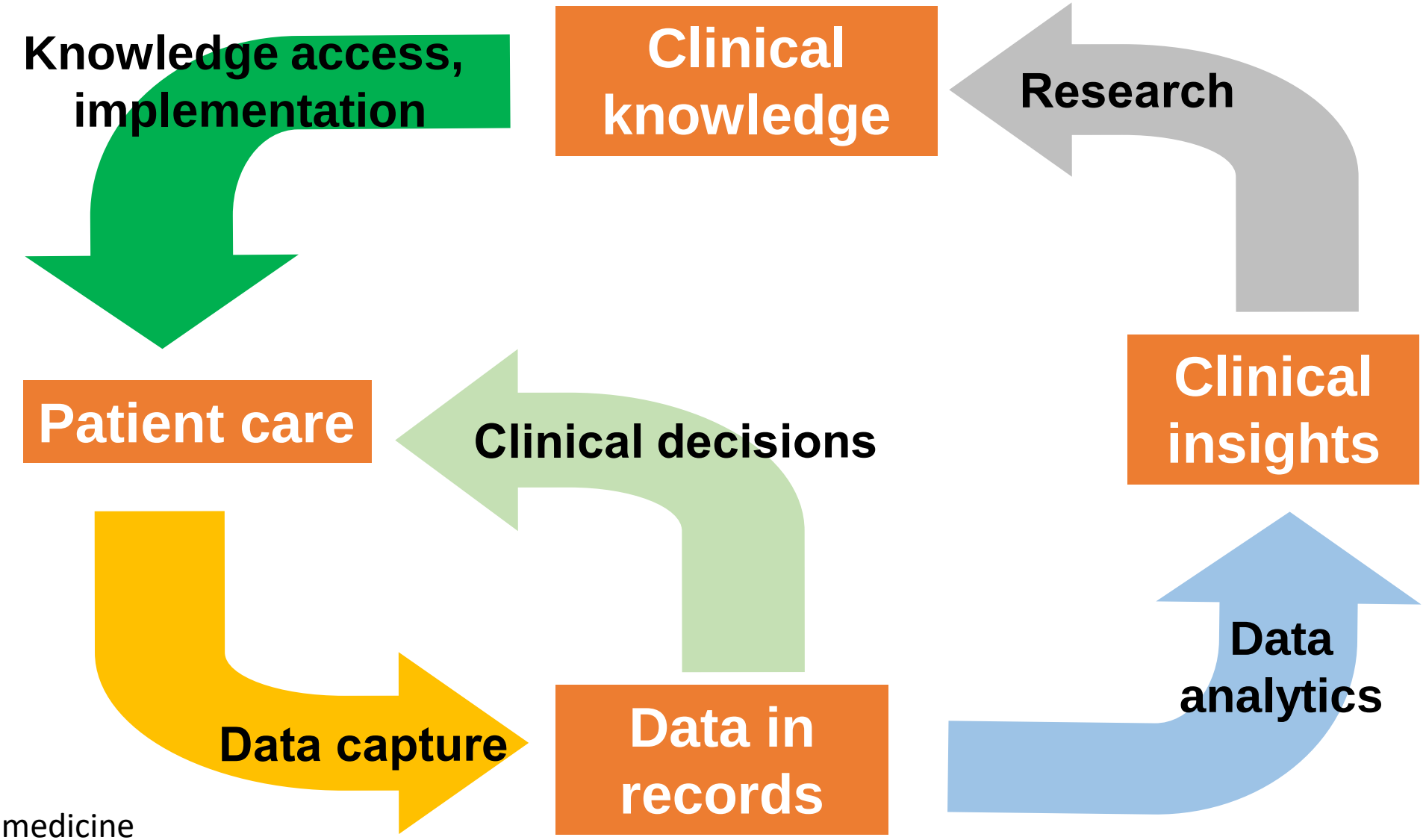
1. Knowledge in medicine: what is it, some of the challenges
2. Evidence that knowledge-based decision support systems improve medical decisions
3. The definition of computable, as opposed to human readable, knowledge
4. How such knowledge is already used in a wide range of software tools in healthcare
5. Current challenges around acquiring computable knowledge
6. The MCBK vision: a global library of computable knowledge objects to address these challenges
7. Some technical and other barriers that need to be overcome

What is information ?

"The commodity that reduces uncertainty" - Claude Shannon, 1949

"Organised data or **knowledge** used to inform decisions" – Ted Shortliffe, 1990

Cycles of information in health care

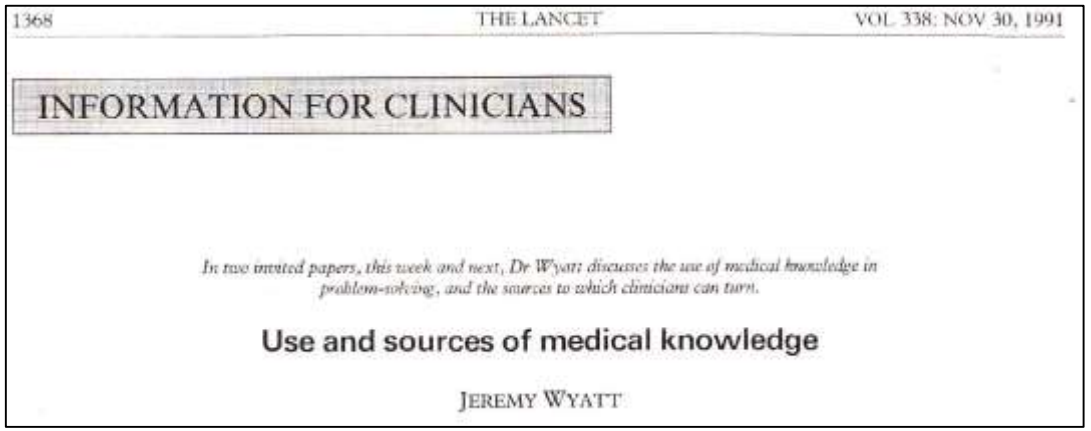


Comparing patient data with clinical knowledge

	Patient data	Clinical knowledge
Who it applies to	A single patient	Every patient
Where it originates	A single patient	Research on many patients
Forms it can take	Numbers, codes, text, images, sounds…	Intuition, spoken word, written text, computer-based text, computable knowledge
Privacy issues	Significant, even if “anonymised”	Not applicable
Intellectual property issues	Not at individual patient level	Significant
Scale of activity	Major global market in EPR etc.	Small, fragmented market in computable knowledge

So, what +is+ knowledge ?

1. “Understanding of, or information about, a subject that you get by experience or study, either known by one person or by people generally” – Cambridge dictionary
2. “The property of intelligent agents that allows them to reach their goals efficiently” – Alan Newell, AAAI Presidential address, AI Magazine 1981
3. Information to support clinical decisions that can be applied across many patients – Wyatt, Lancet series, 1991


1368 THE LANCET VOL 338: NOV 30, 1991

INFORMATION FOR CLINICIANS

In two invited papers, this week and next, Dr Wyatt discusses the use of medical knowledge in problem-solving, and the sources to which clinicians can turn.

Use and sources of medical knowledge

JEREMY WYATT

Explicit knowledge and tacit knowledge

The focus of this webinar

Explicit knowledge can be readily captured, written down & communicated without ambiguity (learning by reading)

Tacit knowledge is intuitive, can only be learned by experience and passed on over a period of apprenticeship (learning by doing - and from mistakes)

Welded titanium necklace
Made by JW using skills learned from experts & many mistakes over last 25 years

Who needs clinical knowledge, what for ?

User group	Use cases for clinical knowledge
Members of the public	Assessing health-related risks & how to manage them; what to do about acute symptoms
Patients	Self management: how to adjust therapy; when to seek clinical contact, and how urgently
Clinicians	To guide diagnosis, prognosis, investigation, treatment…
Public health workers	To assess and manage population risks
Medical publishers	To provide content for paper & online publications and decision support systems
Software developers	To support development of decision support systems, apps, medical devices, chatbots, clinical robots…

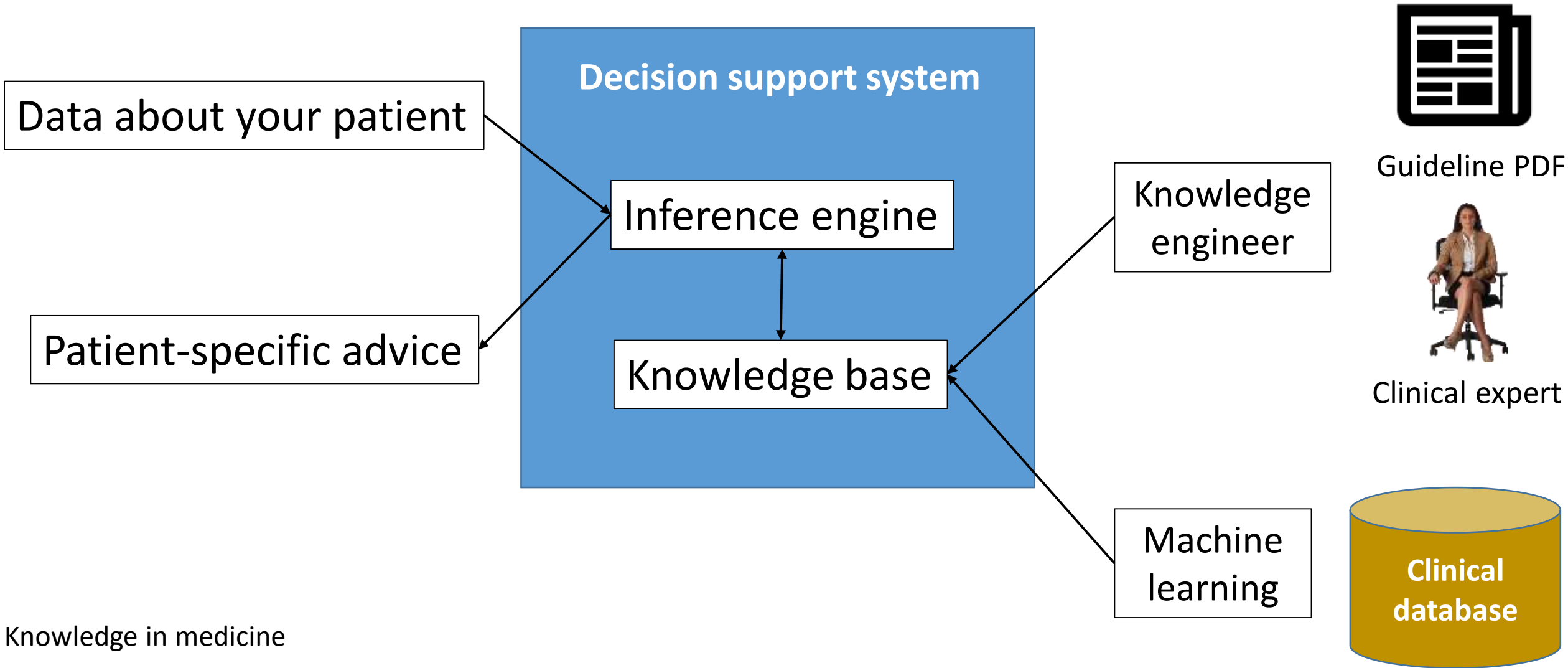
Some of the challenges posed by clinical knowledge

1. Size of the clinical knowledge base: 3 million facts (Gorry 1976)
2. Rate of change: doubling time 19 years (Wyatt 1991)
3. Delays in getting new knowledge into practice: 18 years (Balas 2001)
4. Synonyms, abbreviations, ambiguity (eg. PE = pulmonary embolus or pre-eclampsia ?)
5. Variable quality, from expert opinion to systematic review evidence

Knowledge based decision support

Development process

In use



Evidence: decision support impacts clinical practice

Six McMaster systematic reviews analysing 166 RCTs of CDSS supporting diagnostic tests, prescribing, drug dosing, prevention, chronic disease management and acute care

Overall, CDSS improved:

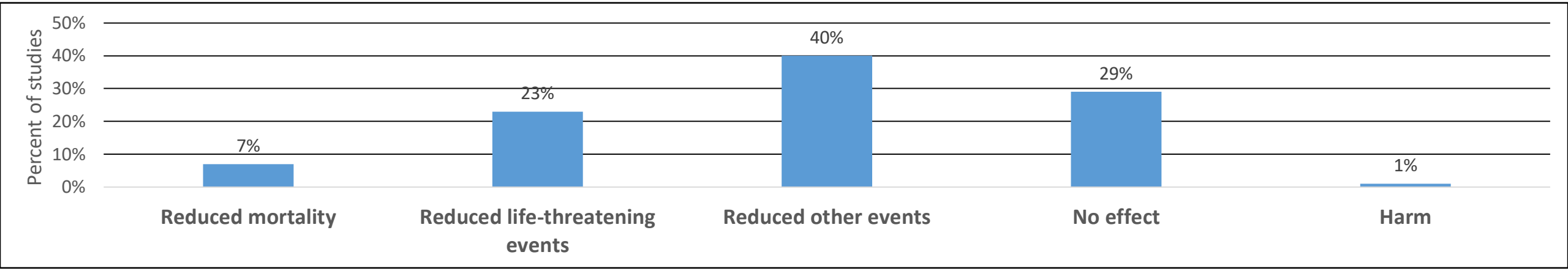
- Clinical decisions or the care process in 52-64% of trials
- Patient outcomes or surrogate outcomes in 15-30% of the trials that studied impact on patient health

Roshanov et al, BMJ 2013

Evidence: clinical knowledge systems benefit patients

Systematic review of 70 patient outcome studies by Varghese et al (JAMIA 2018;25:593–602):

- 33 prospective nonrandomized studies with pre/post analysis or cohort studies (47%), 20 randomized controlled studies (28%), 18 purely retrospective studies (25%)
- 70% of studies showed patient benefit (see graph); 29% no patient benefit, 1 showed harm (blood glucose system ***increased*** hypoglycaemic events)
- High effect scores & medium / low risk of bias for CDSS in 6 of the 24 disease / care groups: managing blood glucose or blood transfusion; preventing physiological deterioration, pressure ulcers, AKI or VTE
- 72% of the implemented algorithms were rule-based, 6% Bayesian nets, 22% not stated



Difference between computer-*based* and computer-*executable* ("computable") knowledge

Human readable knowledge is held and shared in text format for people to read, eg. paper or PDF patient leaflets or guidelines

Computer-*executable* knowledge is held in a format that can be applied by the computer to carry out a task, such as:

- Carrying out a calculation (eg. BMI)
- Interpreting a lab test result (eg. ECG or lung function tests)
- Displaying an alert or reminder (eg. prescribing alert)
- Providing advice or decision support (eg. on diagnosis or warfarin dose)
- Instructing a syringe pump or surgical robot

(Friedman et al, Learning Health Systems 2019)

Example: NICE pathway on gestational diabetes

Human readable text:

At the booking appointment, determine the following risk factors for gestational diabetes:

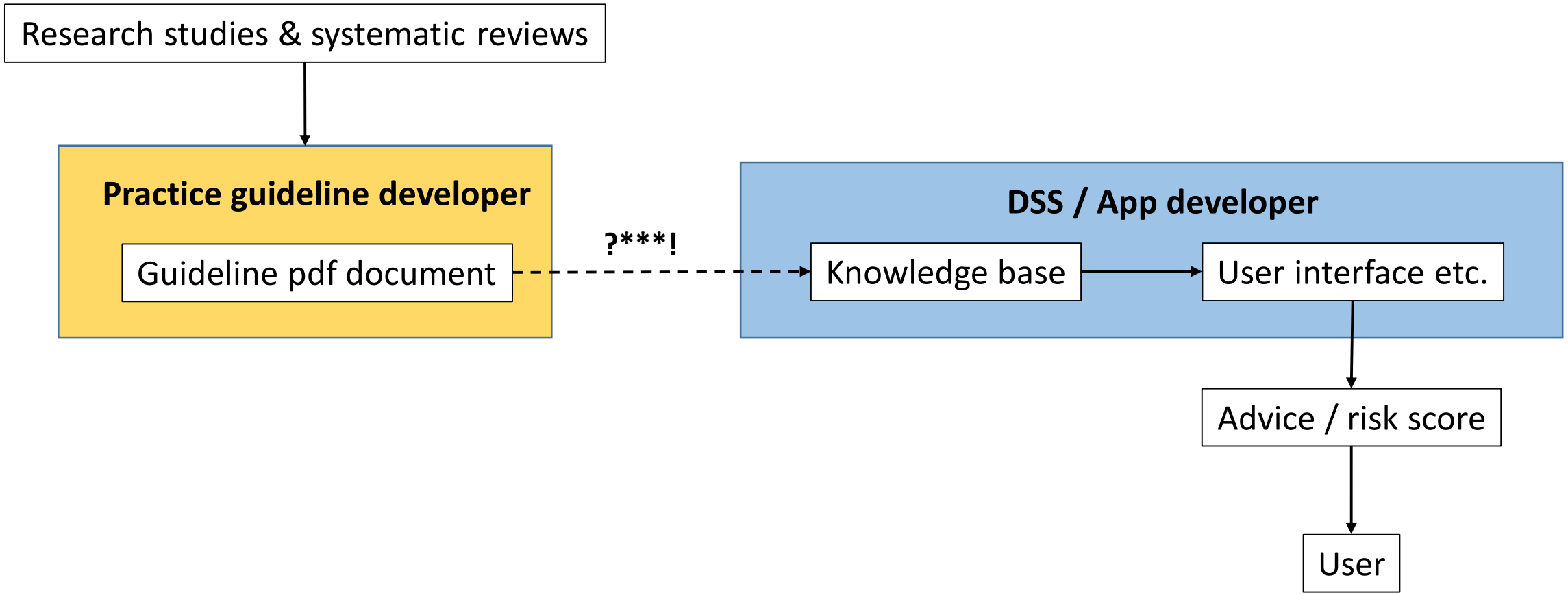
- BMI above 30 kg/m2
- previous macrosomic baby weighing 4.5 kg or above
- previous gestational diabetes
- family history of diabetes (first-degree relative with diabetes)
- minority ethnic family origin with a high prevalence of diabetes.

Computer executable text (CQL dialect):

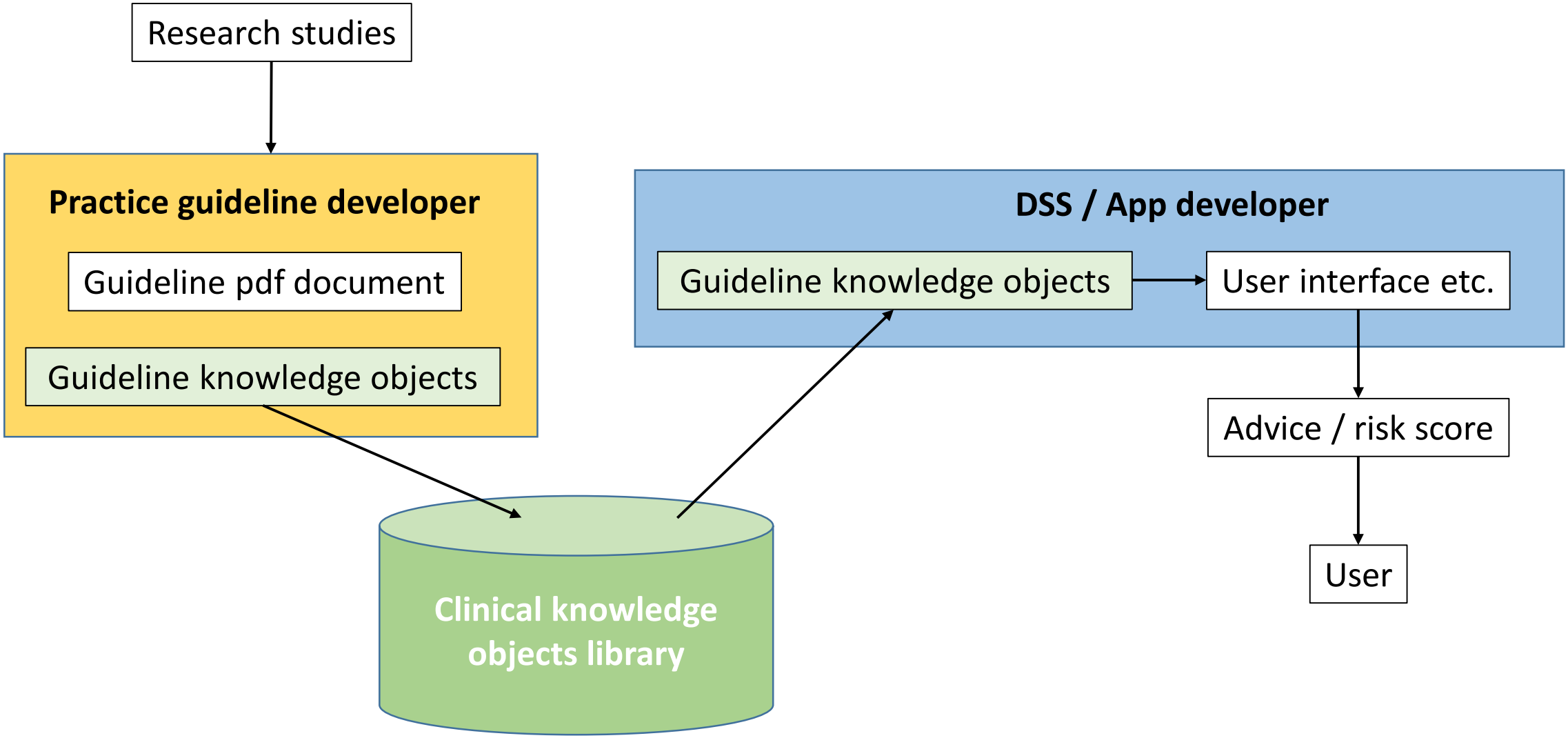
Include CMS153_Common version ‘2’

Define GestDiabetesRisk: exists (CMS153_Common.ConditionsIndicatingGestDiabetes) or exists (CMS153_Common.LaboratoryTestsIndicatingGestDiabetes) or exists (CMS153_Common.FamilyHistoryIndicatingGestDiabetes)

The current knowledge chain

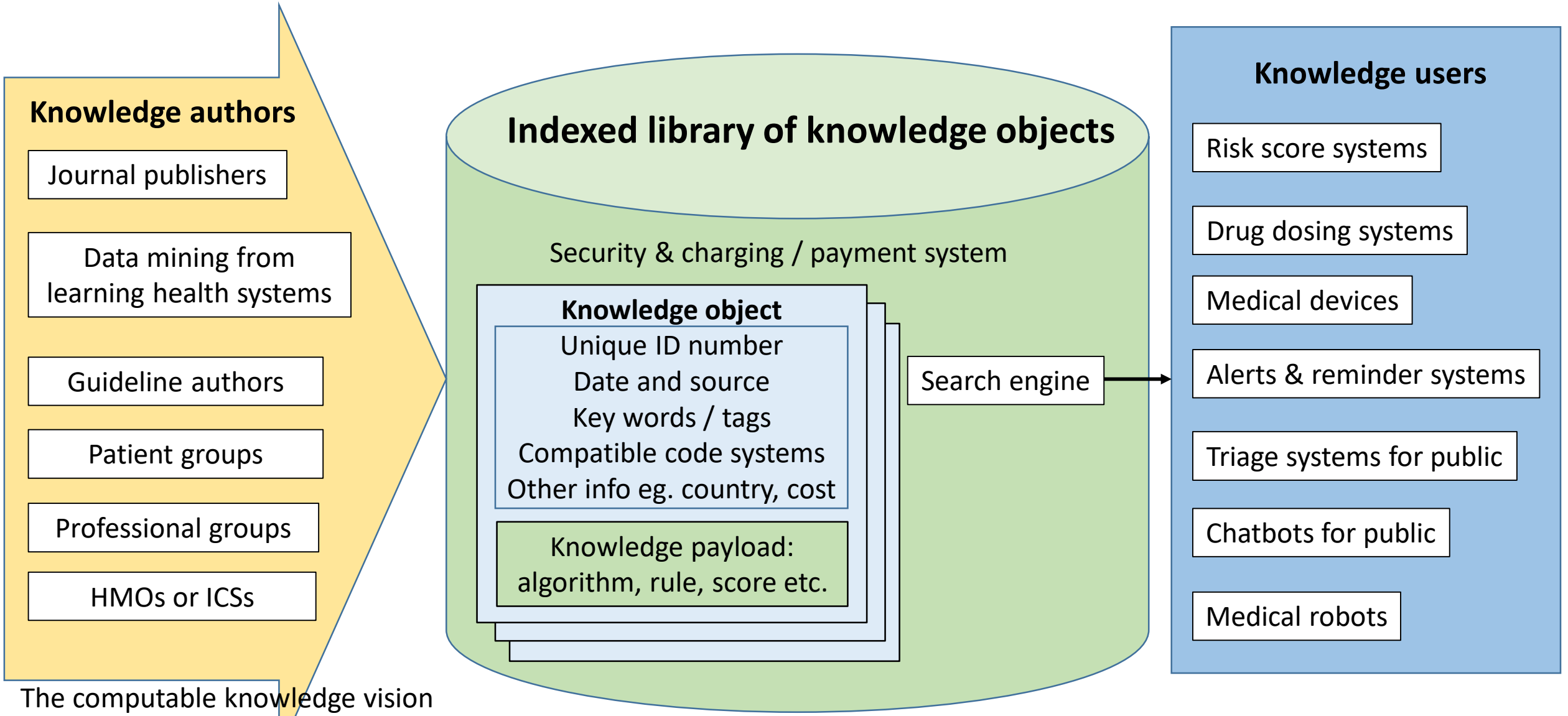


The knowledge chain we need



The computable knowledge vision

Vision of the Mobilising Computable Biomedical Knowledge (MCBK) coalition



The computable knowledge vision

Some computable knowledge challenges

1. **Sustainability:** helping knowledge authors justify the extra work of authoring computable knowledge, as well as human-readable text
2. **Building user trust in the library,** by:
   a) Quality assurance / validation of knowledge objects prior to library acceptance
   b) Preserving context of individual knowledge objects & their provenance and integrity
   c) Keeping knowledge objects up to date when new study or guideline published
   d) Ensuring safe transfer of knowledge objects to systems using different clinical codes or semantics (QRisk2)
   e) For clinical decision support, ensuring that objects based on NICE guideline or systematic review overrule objects based on single study, clinical audit or opinion
   f) Continuing quality improvement (eg. by routing user comments to knowledge object authors)
   g) Establishing lean MCBK governance structures & mechanisms

Some technical and other barriers to overcome

What skills do clinicians need to use these tools?

Clinical work:

- Recording accurate, coded pt. data to support machine learning
- Knowing what AI is, recognising when & where it is being used in NHS
- Trusting and following AI-based advice *when this is correct*
- Recognising & reporting errors in AI-based services

Educational activities:

- Educating colleagues about appropriate use of AI to support their work
- Recommending appropriate AI services to patients

Advisory work:

- Helping NHS organisations procure good quality AI systems
- Investigating adverse incidents involving AI or decision support

https://www.gettyimages.co.uk/photos/

UK MCBK activity coordinated by Faculty of Clinical Informatics & BCS

Aim: to support UK organisations to adopt high quality computable knowledge and realise its benefits for patients, professionals and the NHS, by:

1. Promoting networking between interested organisations
2. Developing a prioritised list of issues, actions to take and leaders for these
3. Identifying suitable host organisations and resources
4. Building on our Oct 2019 workshop with further meetings and activities, eg. Feb 2021 conference hosted by FCI

See:

- MCBK home page + workshop videos: https://www.facultyofclinicalinformatics.org.uk/mcbk/
- BMJ H&CI supplement (7 articles): https://informatics.bmj.com/content/27/2

Better Care Catalyst workstream

Aim: to improve knowledge flows within and beyond HDR UK's Better Care programme

Scope: tacit and explicit (computable) knowledge

Activities:

- Survey and interviews on current knowledge exchange habits and wishes
- Audit of clinical knowledge products from Better Care programme
- Option appraisal of current computable knowledge standards & tools
- Clinical Knowledge Hack Day using selected tools in December

Led by Jeremy Wyatt & Philip Scott (Portsmouth); hosted by FCI for 6 months (ends Feb 2021)

See: https://www.hdruk.ac.uk/projects/building-communities-to-share-and-use-knowledge-tools-and-insights-for-better-care/

Conclusions

1. Knowledge is central to clinical practice, but is hard to manage
2. There is good evidence that knowledge systems improve clinical decisions and patient outcomes
3. Computable knowledge is the core of these decision support and other systems, but is hard to capture, locate and include
4. A global clinical knowledge object library could help & is within reach, but raises a number of trust and technical issues
5. The FCI MCBK SIG is working with US and other groups to progress this agenda
6. Finally, please complete the FCI MCBK expression of interest form at: https://forms.gle/zJWugA8AHvmskeU97