Why hybrid Case-Based Reasoning will Change the Future of Health Science and Healthcare
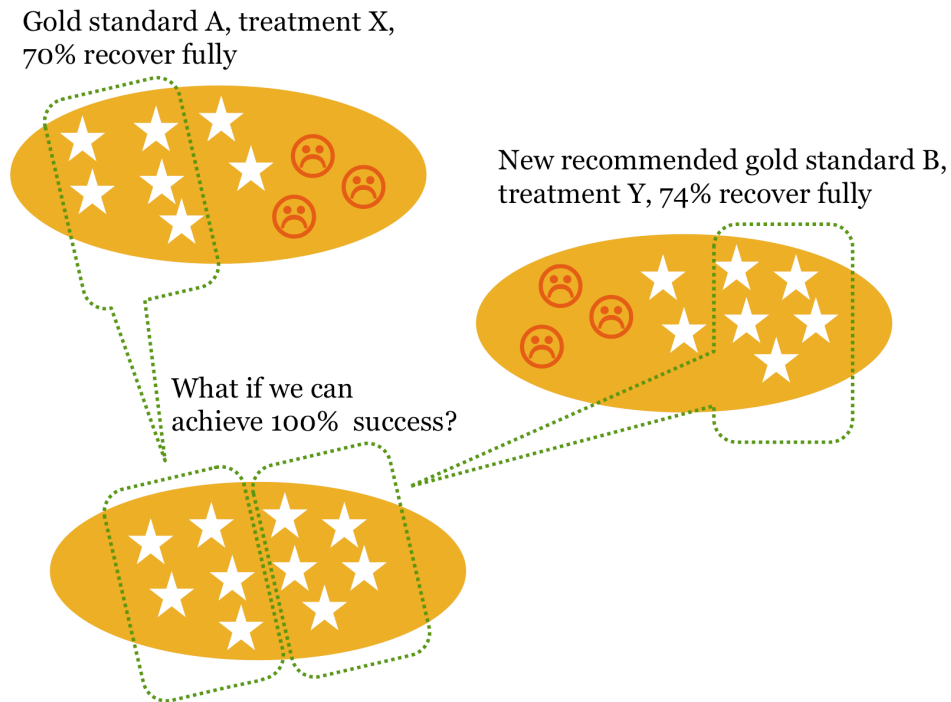
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Abstract, The rapid development of the medical field makes it impossible even for experts in the field to keep up with new treatments and experience. Already in 2010 all medical knowledge doubled in 3,5 years, to keep up to date with all development even in a narrow field is today far beyond human capacity. The need for decision support is increasingly important to ensure optimal treatment of patients, especially if patients are not "standard patients" matching a gold standard treatment. By ensuring confidentiality and collecting structured cases on a large scale will enable clinical decision support far beyond what is possible today and will be a major leap in healthcare.

Already in 2010 all medical knowledge doubled every 3.5 years and is expected to double every 7 months in 2020 [1]. 20 years ago physicians met and discussed medical cases over a cup of coffee, an efficient way of sharing experience and disseminating knowledge. Times are changing; physicians say they don't have time for this any more. In a modern and efficient healthcare organisation there is no longer room for experience sharing and patients are treated according to guidelines. Many physicians I have discussed with admit that the consequence is that as much as 30% of patients don't receive optimal treatment. The amount of medical knowledge is already huge, so it often takes years for new results to spread and even specialists are not able to keep up to date with all developments in their own area. Also some physicians mentioned the use of "golden standard" having the consequence that not all patients get an optimal treatment on an individual level [2]. To illustrate this situation Fig. 1 shows what some physicians see as a problem.

The need for more individualized treatment is recognized today, but to make this come true is not easy for a number of reasons, one suggested reason given by a physician is the lack of support in hospitals for individualized treatments "No one questions your actions if you follow a *gold standard* and something goes wrong, but if you divert from it and something goes wrong, you are in a difficult situation". Sharing experience on patients

that do not fit the standard treatment is essential in order to reach a higher degree of individualization. And it is not always possible to wait for evidence. A valuable ability in humans is that we are able to learn from anecdotal cases and improve performance.

Gold standard A, treatment X, 70% recover fully

New recommended gold standard B, treatment Y, 74% recover fully

What if we can achieve 100% success?

Fig 1. If treatment Y is better than treatment X, then it may be tempting to make treatment Y to a recommended gold standard. But what about the 26% which don't get the best treatment? If we can identify which individuals respond best on X and which respond best to Y, we are able to give every patient their optimal treatment.

Key problems to improve with high relevance in the medical area:
- Limited time to share experience among clinicians/physicians.
- Limited time to acquire relevant knowledge/experience related to patients
- Keeping up with all new medical knowledge
- Dissemination of new knowledge and experience at the point of need
- How to individualise treatment of patients so all get an optimal treatment

1. What can Case-based reasoning offer?

Imagine you have a patient in front of you, the CBR system immediately says "your patient's symptoms are very similar to 47 other patients in Europe, where there are 4 different treatments, patients with treatment C recovered within 2 weeks, twice as fast as with treatment A and B, there is no difference in treatment cost. Based on my experience (all my cases) a modification of treatment C is recommended (due to your patient having diabetes). In France there is an alternative treatment D (8 patients) with recovery time of less than 10 days, the cost for this treatment is 5 times higher". The system offers

- Advice at the point of care tailored for the patient and physician
- Dissemination of experience from new treatments/procedures
- Second opinion for an experienced clinician, transfer experience to a less experienced clinicians
- It can explain and justify all its conclusions and findings

We can provide all this with CBR and I cannot see how this can be solved without case-based clinical decision support systems. All the different foundational methods and techniques are already available in research, to mention some [3,4,5], but to achieve a transformation of the healthcare system we need a large scale approach since it requires a change in how patient cases are recorded and stored in order to preserve privacy and enable experience reuse.

To achieve this we need more elaborate case structures enabling hybrid case-based reasoning including experience sharing, knowledge discovery, data mining. Many approaches also address distributed knowledge sources [8] and under uncertainty [9] and case-based reasoning theory is today increasingly diverse and advanced able to address challenges preciously difficult to solve [10] and there is progress in integrating electronic patient record system with CBR [11]. One approach developed for medical application used in the Pain-Out project [5,6] is a two-layered case structure, see Fig. 2.
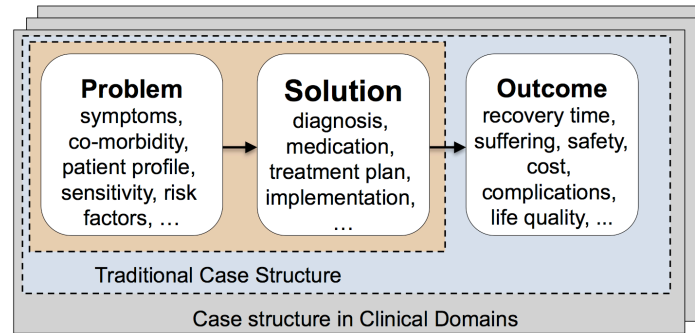
Fig 2. Extended case structure used in clinical application [3]

When explaining the concept of case-based reasoning for clinicians, the response is often "such a tool would dramatically change and improve my work and healthcare":

- Patient records become sources of experience and knowledge and provide supplementary information not currently accessible for diagnosis and treatment by clinicians at the point of care
- Clinicians will be able to easily and instantly share experience around specific case issues
- Dissemination of new clinical experience will be efficient and at the point of need.
- Patients will receive personalised and more informed diagnosis and care.

2. Example case

One project where we explored some of the issues is in the PAIN-OUT decision support tool. With over 40,000 cases as our "experience base" we developed a tool, giving clinicians relevant information specifically compiled for the patient at hand (comorbidity, age, weight and other factors taken into account). Similar patients are identified amongst the cases and the treatment and outcome is analyzed and presented.

Fig 3. Example of a clinical decision support tool that provides physician with personalised information tailored for the patient at hand.
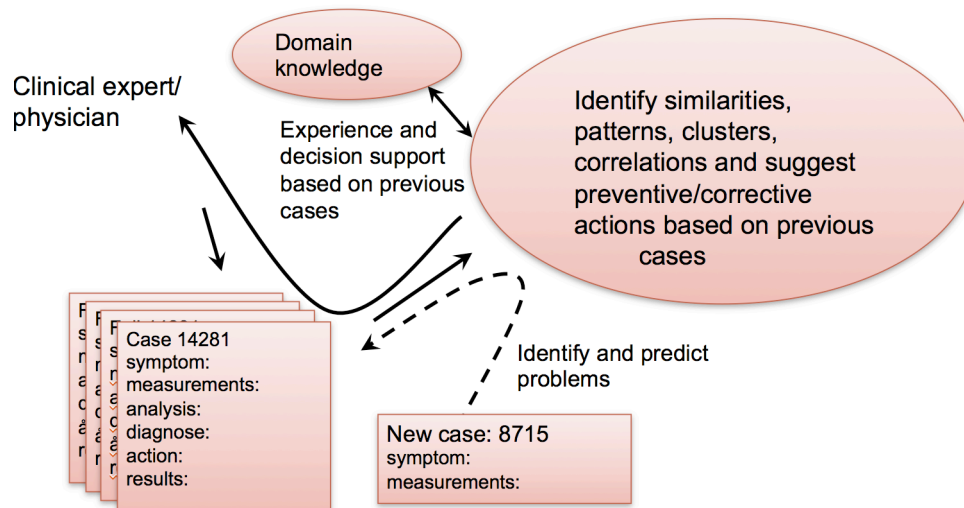
Fig 4. Example of how medical cases can be used to support clinicians.

3. Conclusions

We have summarized some important issues where case-based decision support can help.

Clinical case based reasoning enables:
- second opinion for an experienced clinician
- dissemination of experience from new treatments/procedures
- transfer experience to a less experienced clinician
- link to relevant research and clinical studies
- other clinicians experience (annotated cases)

The requirements are that cases are collected where symptoms, diagnosis and outcome of treatment is recorded. In many medical registries this is unfortunately not available, especially the outcome is rarely recorded and it is often difficult or impossible to reconstruct the cases.

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