The Use of Extensible Markup Language (XML) to Analyse Medical Full Text Repositories – An Example from Homeopathy

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Abstract: Extensible Markup Language (XML) is one of the most popular web languages in the life science used for for Semantic Data Analysis in various fields of clinical research. One of these fields is the processing of medical full texts. To extract meaningful information out of natural texts is one of the challenges when dealing with huge text repositories. We present an application of XML together with linguistic algorithms in the processing of texts from a homeopathic materia medica. Our approach enables the user not only to search within the symptom descriptions but also offers special features like sequential search within the results or the comparison of homeopathic remedies. However user demands of day to day practice and terms of information technology have both to be taken carefully into account to further develop this prototype.

1 INTRODUCTION

Extensible Markup Language (XML) is one of the most popular semantic web language in the life science with more than 900 publication between 1999 and 2010 in PubMed (Ostermann et al., 2014). Today it is applied in knowledge transfer in the life science (Murray-Rust, 2000) In this field XML has managed to become an important tool in clinical laboratory procedures (Saadawi and Harrison, 2003) but its way into patient care still seems to be far behind the possibilities XML is offering.

In particular the capability of Internet Browsers to read, edit and analyse XML documents creates a variety of opportunities for Semantic Data Analysis (SDA) facilities to be incorporated into clinical applications (Bompani et al., 2002).

XML, when combined with web services, semantic data analsis and scripting languages such as Java script, can be used to offer a huge amount of functionality for the user including text retrieval and the generation of summary data through a standard web-browser.

With regards to medical full texts, searching for a certain information sometimes is crucial. As already pointed out by Grivell in 2002 “natural language provides a considerable challenge for algorithms to extract meaningful information from natural text.”

This even more becomes a complex problem when dealing with huge repositories from the field of traditional medical systems. In particular, machine readable dictionaries with a codification of domain knowledge and literature metadata in accordance with a generic and extendible XML scheme model have been shown to be suitable in this context Ostermann et al., 2009). One open problem in in this context is the semantic processing of the so called Materia Medicae. Such repositories contain structured data on medical symptoms and the corresponding remedies i.e. from the field of phytotherapy or, like in our case, from homeopathy.

With a tradition of 200 years of patient care, homeopathy is one of the oldest integrative medical systems in the field of Traditional European Medicine. An essential part of homeopathic case taking is the conduction of a comprehensive anamnesis followed by individualized finding of a remedy that fits the conditions the patient describes. This is called repertorisation and today is done with the help of computer programs using modern database technology (Ostermann et al., 2012).

Accoring to our own review and with respect to other personalized approaches in e-health (Lee et al., 2008), XML-based processing of such vast resources might be beneficial in the complex process of homeopathic prescribing.

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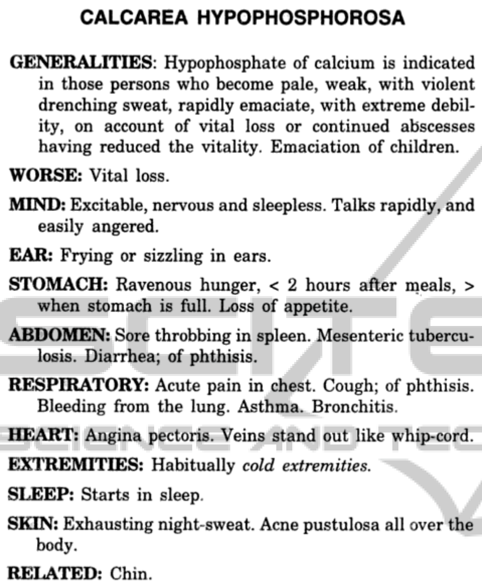
2 MATERIAL AND METHODS

Phataks' Materia Medica contains 419 different homeopathic remedies described in their symptoms in a Head-To-Toe Scheme. Fig. 1 illustrates this structure on the example of Calcerea Hypophosphorosa ($CaHPO_4$):



CALCAREA HYPOPHOSPHOROSA

GENERALITIES: Hypophosphate of calcium is indicated in those persons who become pale, weak, with violent drenching sweat, rapidly emaciate, with extreme debility, on account of vital loss or continued abscesses having reduced the vitality. Emaciation of children.

WORSE: Vital loss.

MIND: Excitable, nervous and sleepless. Talks rapidly, and easily angered.

EAR: Frying or sizzling in ears.

STOMACH: Ravenous hunger, < 2 hours after meals, > when stomach is full. Loss of appetite.

ABDOMEN: Sore throbbing in spleen. Mesenteric tuberculosis. Diarrhea; of phthisis.

RESPIRATORY: Acute pain in chest. Cough; of phthisis. Bleeding from the lung. Asthma. Bronchitis.

HEART: Angina pectoris. Veins stand out like whip-cord.

EXTREMITIES: Habitually *cold extremities.*

SLEEP: Starts in sleep.

SKIN: Exhausting night-sweat. Acne pustulosa all over the body.

RELATED: Chin.

Figure 1: Description of the homeopathic remedy Calcerea Hypophosphorosa in its symptoms in a Head-To-Toe Scheme (Phatak 2011).

For every remedy a more or less detailed description comparable to the one given in Fig. 1 was ripped into approx. 25.000 phrases resp. sentences divided either by a full stop or a semicolon. Phrases were processed into an index by linguistic algorithms, and together with additional discriminating information (ADIs) for example, the logical subset (i.e. a remedy or a head to toe section) a phrase belongs to, an inverted file structure is created (Fig. 2; for an overview see Zobel and Moffat, 2006).

In our example of Calcerea Hypophosphorosa *stem$mr" denotes the decomposition of a search term i.e. the search term "drenching" leads to "drench$~ing". Note that front truncation information (marked with a "*") and umlauting are features specially designed for German language and do not occur quite often in English language (i.e. for composition terms like "Night-Sweat" which in the case of "nightsweating" would become *sweat$~ing).

Another algorithm decomposes phrases into their linguistic and grammatical entities. In the example of figure one the term "Acute pain in chest", the word "pain" is the subject modified by "in chest" and restricted by "acute", whereas in the phrase "chest pain in acute bronchitis" constructed by the same words, the roles of modifying and restricting terms change. Thus, although the textual phrase consists of the same words, the ranking of the search results will be different because of the grammatical relation between the words. Words therefore are no longer regarded as textual 'singularities', but are recognized in their syntactic-semantic interrelation. (Zillmann, 2000).

The complete vocabulary of the material medica with exclusion of content notes such as page numbers and stopwords such as "the","an" or "and", which were filtered out prior to the processing is stored this way in a Prefix-B-tree which stores the strings in lexicographic order with head and tail compression as described above (Bawa et al., 2005).

Let $C=\{d|d=1 \ldots D\}$ denote the corpus containing a total of D datasets d and let $W_d=\{w_i^d|w_i^d \in d; i=1\ldots n\}$ denote the set of all words w_i^d of the dataset. Then an address vector $\vec{w}_i^d=(w_i^d, a_1, a_2, \ldots a_k)$ is defined where $a_1, a_2, \ldots a_k$ denote additional coded information about syntactical and morphological attributes of the word.

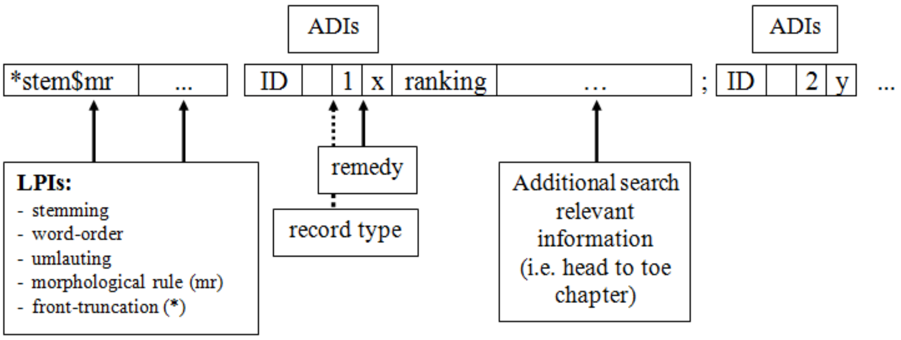


Figure 2: Schematic description of an inverted file structure with linguistic processing information in the front and additional discriminant information (ADIs) in the back of the coding (adopted from Ostermann et al., 2009).

Then $\tilde{W}_d = \left\{ \vec{w}_j^d \middle| ; i = 1 \ldots \tilde{n} \right\}$ is called the index of the dataset d and $\tilde{W} = \bigcup \tilde{W}_d$ is called the index of the whole database. Finally the terms $S = \left\{ s_j \middle| s_j ; j = 1 \ldots m \right\}$ of the search query S are defined. Again, according to the construction of $\vec{w}_i^d$ a search vector $\vec{s}_j = \left(s_j, a_{1,} a_2, \ldots a_k \right)$ is defined.

The quality function is then defined as

$$Q_d(S) = Q_m + \sum_{j=1}^{m} \sum_{i=1}^{n} q_i \left(\vec{w}_i^d, \vec{s}_j \right) \leq 100 \text{,}$$

where $q_i \left(\vec{w}_i^d, \vec{s}_j \right)$ denote additional quality criteria functions (i.e. correct flexion, correct position and order of the words, containment in a compound word, irregular plurals) and Q_m denotes a fixed accuracy parameter (in our case Q_m=45). Together with a quality threshold $Q_t = Q_m - \delta_m ; \delta > 0$ defined as the lower bound for the quality of a dataset, every dataset d with a value $Q_d(S) \geq Q_t$ is presented as a result of the search query S. Datasets with a higher ranking then will be placed in a higher position than those with a lower ranking (Fig. 3).

One important feature is given by the “Search within the results” feature. As homeopathic diagnosis is based on a sequential process of adding up symptoms of a patient, this process has to be integrated in the search architecture. Thus the process described in Fig. 3 is repeated within the search results: In a first step the therapist submits a query comprising terms describing the patients symptoms i.e. “throbbing headache in the morning”. This query is then processed via linguistic algorithms resulting in a list of possible remedies. The therapist now can modify his search query by adding a second symptom i.e. “chest pain with cought”. Based on the results of the first search query given by the record-IDs, the search engine runs a second query which refines the first query. The process is repeated until a lower bound of 10 remedies is reached.

The results of a search query are represented in XML-structured metadata and delivered to the clients web browser. At the client side XML-data is processed via Extensible Stylesheet Language Transformations (XSLT). Fig. 4 displays a result for the search query “starker Nachtschweiß” (engl: exhausting night-sweat”).

As can be seen in this example, Remedies are ranked higher, when the search query “starker Nachtschweiß” is not modified by other descriptors. This is the case in the first three hits “Taraxacum”, “Ledum palustre” and “Ammonium muriaticum” which completely contained the phrase “starker Nachtschweiß” (or its plural) seperated by punctuation from other phrases and thus *Q = 100%.* In the next four hits the phrase “starker Nachtschweiß” is modified i.e. in hit 7: “starker Nachtschweiß, nach Schwefel riechend” (engl: smelling like sulfur). Thus the quality function is reduced to *Q=98% resp. 97%.* In the last case of “Calcera phosphorica” Q is reduced to 88% because in the full text the restricting adjective “exhausting” is parenthesized: *[starker].*

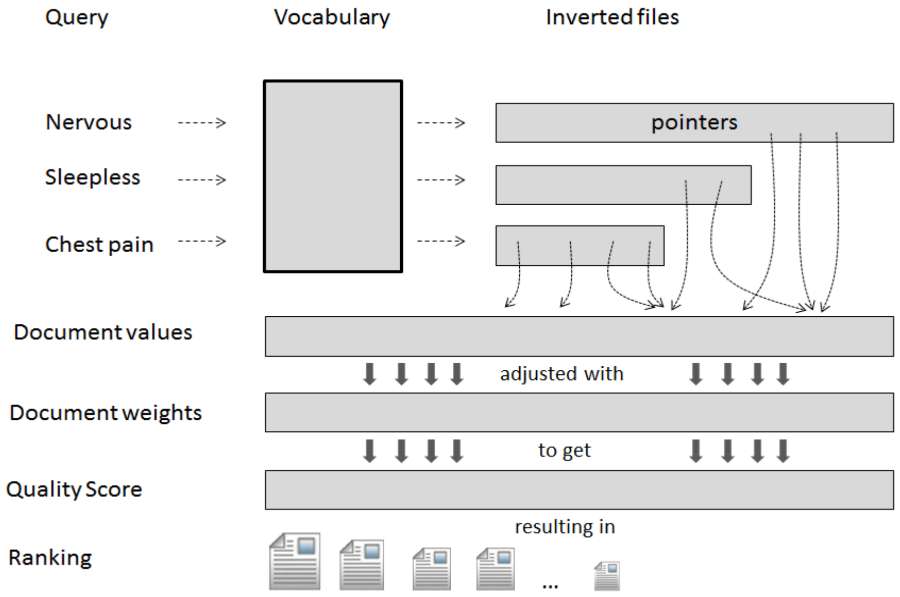
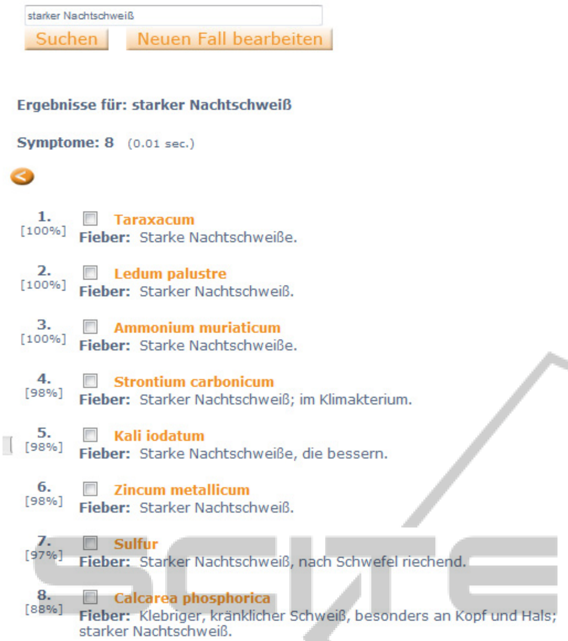


Figure 3: Schematic description of the relationship between inverted file and document quality scores (adopted from Zobel and Moffat 2006).



starker Nachtschweiß

Ergebnisse für: starker Nachtschweiß

Symptome: 8 (0.01 sec.)

1. [100%] □ Taraxacum
Fieber: Starke Nachtschweiße.

2. [100%] □ Ledum palustre
Fieber: Starker Nachtschweiß.

3. [100%] □ Ammonium muriaticum
Fieber: Starke Nachtschweiße.

4. [98%] □ Strontium carbonicum
Fieber: Starker Nachtschweiß; im Klimakterium.

5. [98%] □ Kali iodatum
Fieber: Starke Nachtschweiße, die bessern.

6. [98%] □ Zincum metallicum
Fieber: Starker Nachtschweiß.

7. [97%] □ Sulfur
Fieber: Starker Nachtschweiß, nach Schwefel riechend.

8. [88%] □ Calcarea phosphorica
Fieber: Klebriger, kränklicher Schweiß, besonders an Kopf und Hals; starker Nachtschweiß.

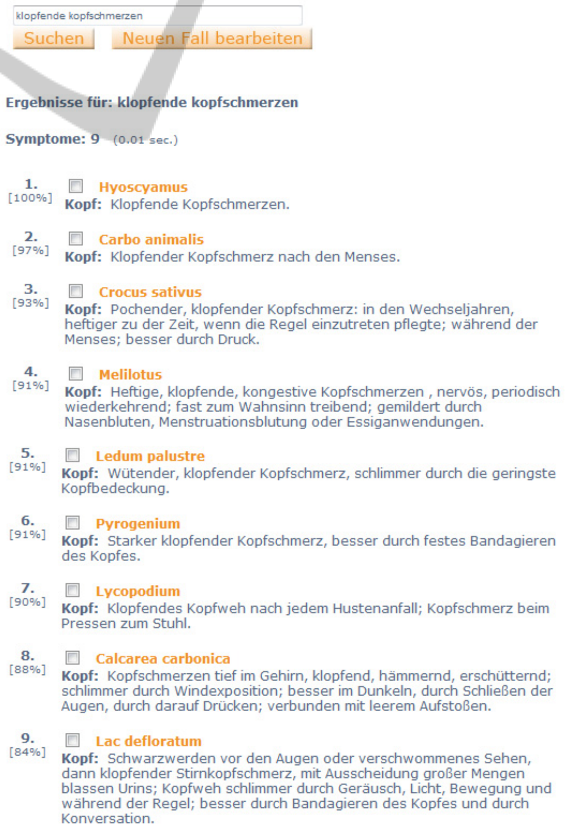
Figure 4: Representation of the search results for “starker Nachtschweiß” (engl.: “exhausting night-sweat”. Please note that our example “Calcerea Hypophosphorosa” is known in the German Version of Phatak’s material medica as “Calcarea phosphorica”.

Another example is given by the search query “klopfende Kopfschmerzen” (engl: “throbbing headache”) in Fig. 6.

Again the first hit finds the complete search phrase “klopfende Kopfschmerzen” as a standalone phrase and thus *Q=100%.* In hit number two the search phrase is modified by “nach der Menses” (engl: “after menses”) resulting in a quality function value of *Q= 97%.* In hit three “Crocus sativus” the search term „klopfender Kopfschmerz“ is found completely, however it is restricted by *“pochender”* (engl. “beating”). This restriction reduces Q to 93%. In the results 4-6 we have the same formal restriction like in hit three, however the search phrase is additionally modified by *“nervös,…”* (engl.: “nervous”) in hit four “Melilotus”, *“schlimmer…*”(engl.: “worsened”) in hit five “Ledum palustre” and *“besser…”* (engl.: “improved”) in hit six “Pyrogenium”. In hit 7 “Lycopodium” we have a German synonym “Klopfendes Kopfweh” which later in the sentence is explained as “Kopfschmerzen”, the exact wording of the search phrase. Hit number eight “Calcera carbonica“ quite intuitively shows that “klopfende Kopfschmerzen” also finds „Kopfschmerzen tief im Gehirn, klopfend“ (engl. “headache, throbbing deep in the brain”) leading to a further reduction of the quality function *Q* to 88%. Finally but is even more important the search term “klopfende Kopfschmerzen” also finds the composition term “klopfender Stirnkopfschmerz” (engl. “throbbing frontal headache”) of Lac defloratum (Hit 9) although with a lower ranking of Q=84% (See Figure 6 for the search results).

```
<record>
<RecordRelevance>91</RecordRelevance>
<RecordNumber>5</RecordNumber>
<RecordLink>/cgi-
bin/CiXbase/phatak5/CiXbase_search?act=search&#3
8;search=sqn&#38;sqn=00021005</RecordLink>
<RecordID>00021005</RecordID>
<DataType>c</DataType>
<RecordType>o</RecordType>
<TitleID>00020968</TitleID>
<cTitle>Ledum palustre</cTitle>
<cKopf>Kopf</cKopf>
<cKeyword>W&#252;tender, klopfender Kopfschmerz,
schlimmer durch die geringste
Kopfbedeckung</cKeyword>
</record>
```

Figure 5: Extract of the XML-representation of the search result no. 5 for “klopfende Kopfschmerzen”.



klopfende kopfschmerzen

Ergebnisse für: klopfende kopfschmerzen

Symptome: 9 (0.01 sec.)

1. [100%] □ Hyoscyamus
Kopf: Klopfende Kopfschmerzen.

2. [97%] □ Carbo animalis
Kopf: Klopfender Kopfschmerz nach den Menses.

3. [93%] □ Crocus sativus
Kopf: Pochender, klopfender Kopfschmerz: in den Wechseljahren, heftiger zu der Zeit, wenn die Regel einzutreten pflegte; während der Menses; besser durch Druck.

4. [91%] □ Melilotus
Kopf: Heftige, klopfende, kongestive Kopfschmerzen , nervös, periodisch wiederkehrend; fast zum Wahnsinn treibend; gemildert durch Nasenbluten, Menstruationsblutung oder Essiganwendungen.

5. [91%] □ Ledum palustre
Kopf: Wütender, klopfender Kopfschmerz, schlimmer durch die geringste Kopfbedeckung.

6. [91%] □ Pyrogenium
Kopf: Starker klopfender Kopfschmerz, besser durch festes Bandagieren des Kopfes.

7. [90%] □ Lycopodium
Kopf: Klopfendes Kopfweh nach jedem Hustenanfall; Kopfschmerz beim Pressen zum Stuhl.

8. [88%] □ Calcarea carbonica
Kopf: Kopfschmerzen tief im Gehirn, klopfend, hämmernd, erschütternd; schlimmer durch Windexposition; besser im Dunkeln, durch Schließen der Augen, durch darauf Drücken; verbunden mit leerem Aufstoßen.

9. [84%] □ Lac defloratum
Kopf: Schwarzwerden vor den Augen oder verschwommenes Sehen, dann klopfender Stirnkopfschmerz, mit Ausscheidung großer Mengen blassen Urins; Kopfweh schlimmer durch Geräusch, Licht, Bewegung und während der Regel; besser durch Bandagieren des Kopfes und durch Konversation.

Figure 6: Representation of the search results for “klopfende Kopfschmerzen” (engl.: “throbbing headache”.

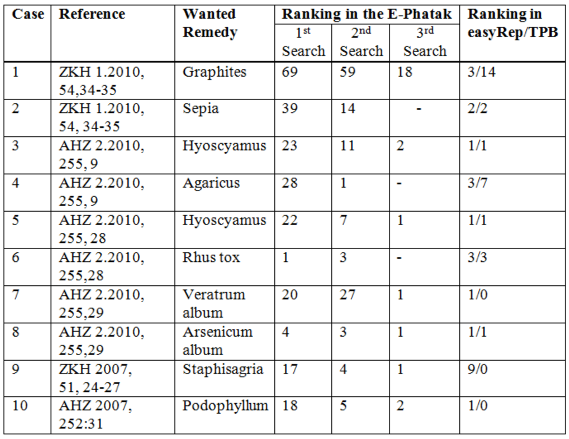
Figures 5 and 6 also demonstrate that structure and layout are separated. This leads to an almost complete interoperability of the metadata and eases the transfer to other information systems like mobile applications.

3 RESULTS

Based on the results of published homeopathic cases we were able to reproduce the results of repertorisation with the E-Phatak. In ten cases listed in Table 1 we were able to reproduce the wanted results with our prototype. A comparison with conventional repertory software "RADAR: easyRep" and the electronic version of the "Bönninghausen's Therapeutic pocketbook" also found promising results

A first evaluation by a focus group of homeopathic physicians and healing practitioners moreover revealed that all evaluators found sequential search to be the key feature and the innovative element of the E-Phatak which should be the subject of further investigations and implementations.

Table 1: Comparison of ranking results of the E-Phatak compared with easyRep and the electronic version of the "Therapeutic pocketbook"



Case	Reference	Wanted Remedy	Ranking in the E-Phatak			Ranking in easyRep/TPB
			1st Search	2nd Search	3rd Search	
1	ZKH 1.2010, 54,34-35	Graphites	69	59	18	3/14
2	ZKH 1.2010, 54, 34-35	Sepia	39	14	-	2/2
3	AHZ 2.2010, 255, 9	Hyoscyamus	23	11	2	1/1
4	AHZ 2.2010, 255, 9	Agaricus	28	1	-	3/7
5	AHZ 2.2010, 255, 28	Hyoscyamus	22	7	1	1/1
6	AHZ 2.2010, 255,28	Rhus tox	1	3	-	3/3
7	AHZ 2.2010, 255,29	Veratrum album	20	27	1	1/0
8	AHZ 2.2010, 255,29	Arsenicum album	4	3	1	1/1
9	ZKH 2007, 51, 24-27	Staphisagria	17	4	1	9/0
10	AHZ 2007, 252:31	Podophyllum	18	5	2	1/0

On the other hand ligustic ranking was found to be difficult to understand for the therapist using the phatak in daily patient care.

One major issue was claimed from the focus group to be the most crucial point when working with the E-Phatak: searching for "throbbing headache" might i.e. miss synonymous phrases like "hammering headache" or "knocking headache", which already has been discussed in the field of full text searching from Beall (2008).

In our case of figure 6 this can be seen in hit number 7 "Lycopodium". Although from a therapeutical point of view it contains what the therapist was looking for (namely "throbbing headache"), it misses a higher ranking due to the linguistic processing, which does recognize a similarity in the semantics but not in the meaning of the phrase itself.

4 CONCLUSIONS

Information technology nowadays has reached almost every part of patient care. In particular electronic systems for decision support of physicians and therapists are major issues in health care informatics. However a recent review of Romano and Stafford (2011) on the impact of such systems on national ambulatory care quality suggests "no consistent association" between the use of clinical decision support systems and better quality in patient care if they are used isolated and are not integrated in routine daily care.

In the field of homeopathy, electronic decision support systems have been introduced and incorporated quite early in patient care with first affordable software applications on the market in the early 1990th. Moreover homeopathy has always made use of the most innovative technology available (Ostermann et al., 2012).

We were able to show how full text searching in homeopathic text repositories can be achieved using XML and XSLT. This technical realisation enables the user not only to search within the symptom descriptions but also offers special features like sequential search within the results or the comparison of homeopathic remedies.

However user demands of day to day practice and terms of information technology have both to be taken carefully into account to further develop this prototype. In particular with regards to several systematic reviews (Boulos et al., 2011, Free et al., 2013), mobile health applications should be taken into consideration for a second launch of the E-Phatak.

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