Explicit Tracking in the Diagnostic Process for Hand Dermatological Practices

Luca Mazzola[1,2], Sara Marceglia[1,*], Stefano Bonacina[1], Francesco Pinciroli[1],
Fabio Ayala[3], Ornella De Pitá[4], and Paolo Pigatto[5,**]

[1] Politecnico di Milano - Piazza Leonardo da Vinci 32, 20123 Milano (MI) Italy
sara.marceglia@polimi.it
[2] Universitá della Svizzera italiana - Via Buffi 13, 6900 Lugano (TI) Switzerland
[3] Universitá di Napoli Federico II, Napoli, Italy
[4] Servizio di Allergologia ed Immunologia Clinica e di Laboratorio,
Istituto Dermopatico dell'Immacolata, Roma, Italy
[5] Universitá degli Studi di Milano, Milano, Italy

Abstract. The complexity of the medical diagnostic practices is faced nowadays mainly with an extensive and long education and with on-the-job training for GPs. Despite these efforts, a big part of the diagnostic process remains implicit in the everyday practicies of skilled professionals. This project aims at an explicit tracking of this ability through the filling-in of an additional importance level for the voices in the Electronic Medical Record. The collected data leads to the extraction of rules that can empower a Decision Support System for hand dermatological practictioner with suggestios and/or diagnoses distribution probability for a specific situation.

1 Background

In almost every country in the world, the education of medical practitioners is complex and requires a relevant amount of resources, in terms of both time effort and skilled professionals dedicated to teaching. After the first educational level, the second level is required to train a fully operational general practitioner (GP).

A relevant issue in GP education is the diagnostic process. The diagnostic reasoning and ability are firstly learnt by observation of - and interactions with

---

* Corresponding author.
** On behalf of the "*Ambulatorio della Mano*". The *Ambulatorio della Mano* is: S. Amato, Ospedale Civico di Palermo; G. Bornacina, Azienda Ospedaliero-Universitaria Maggiore della Caritá, Novara; P. Calzavara-Pinton, Spedali Civili di Brescia; S. Calvieri, La Sapienza Universitá, Roma; M. Congedo, Ospedale Vito Fazzi, Lecce; A. Cristaudo, Istituto Dermatologico San Gallicano IRCCS, Roma; C. Crosti, Universitá degli Studi di Milano; F. Cusano, Ospedale Rummo, Benevento; M. Gola, Universitá degli Studi di Firenze; P. Lisi, Universitá degli Studi di Perugia; P. Patrone, Azienda Ospedaliero-Universitaria, S. Maria della Misericordia, Udine; C. Potenza, Polo Pontino, La Sapienza Universitá, Roma; M. Travaglini, Ospedale A. Perrino, Brindisi.

Fig. 1. The user interface of the specialized *EMR* implemented for the diagnosis of hand skin diseases

- training supervisors or advisors during medical education, and then improved by the growing experience in everyday practice [1]. Making a diagnosis requires evaluating a large number of objective and subjective parameters that are not always available all together, and that may be acquired during the process itself, thus introducing uncertainty.

In dermatology, hand skin pathologies are difficult to be diagnosed because they are characterized by similar signs and symptoms [2] that can be correctly interpreted only by highly experienced and trained specialists. Recently, the differential diagnostic process ([3], [4], [5]) has been applied to hand skin pathologies. Performing a differential diagnosis, timely recognizing the disease and promptly referring the patient to the appropriate specialized center are hard tasks for an inexperienced GP. Wrong diagnoses and thus inadequate therapies or treatments can worsen patients conditions.

2   Objective and Significance

The objectives of this work are: first, to track the diagnostic process performed by specialized dermatologists about the differential diagnosis of hand skin pathologies characterized by similar signs and symptoms; second, to test whether the information collected during the tracking would support better uncovering of the process [5]; third, to design and develop a computerized system that can enable GPs in diagnosing hand skin pathologies appropriately [6] and [7].

This will ground the creation of a Decision Support System (DSS) for the differential diagnosis of hand skin pathologies that will facilitate GPs daily practices. The significance of this work is twofold: first, this could help to increase the correctness rate of diagnosis performed by the GPs - or at least to make them aware of the need of a second specialized consultation. Second, the collected information and the implicit diagnostic pathway (or rules) can lead to better understand the usual way of reasoning followed by specialists for hand skin disease diagnosis.

3   Methods

We designed and implemented a specialized Electronic Medical Record (EMR) system [8], to support the process of differential diagnosis of hand skin pathologies. Specifically, the pathologies considered are divided in two classes: primary hand skin pathologies and secondary hand skin pathologies in which the hand signs and symptoms are the epiphenomenon of another disease:

1. **Primary pathologies**
   (a) DAC (Contact Allergic Dermatitis)
   (b) DCI (Irritant Contact Dermatitis)
        i. DAC + DCI
   (c) Atopic eczema
        i. Atopic eczema + DCI
   (d) Vescicular eczema
   (e) Hyperkeratotic eczema
   (f) Nummular eczema
2. **Secondary - other pathologies**
   (a) Psoriasis
   (b) Palmoplantar keratoderma
   (c) Superficial cutaneous mycoses
   (d) Continuous acrodermatitis
   (e) Pityriasis rubra pilaris

Based on this list of pathologies and their signs and symptoms, we designed the EMR contents together with trained specialists [9] belonging to the Italian reference centers for hand dermatology called "Ambulatorio della Mano", thus ensuring its clinical correctness and usefulness[1].

Then, the implemented EMR was re-assessed by specialists in the field who did not participate in its design, to prevent from possible biases introduced by personal experiences of the designers.

The EMR comprises an explicit tracking system that records a personal score (in a 0-5 range) given to the collected information by the specialist during a patient encounter. The question underlying the scoring phase is: how much was this

---

[1] For the full list of the fields included in the EMR and the scales adopted, please contact: *Paolo Pigatto – pigatto@unimi.it*

information (e.g. patient's gender, age, parts of the hand with altered skin) important/useful to diagnose patient's disease? The scoring phase allows to uncover a crucial step of diagnostic reasoning usually implicit in specialists decision.

Fig. 2. The input forms for Modified Total Lesion Symptom Score ($mTLSS$) and Physician's Global Assessment (PGA) scales

More than one visit is needed to finalize the diagnostic process as either different symptoms spontaneously emerged during time, or the results of prescribed diagnostic tests become available. So, the EMR system is able to track patients in all the encounters they attended. This is achieved by pre-filling out forms with patient information, after the patient identification code is inserted. Furthermore, the system facilitates the practitioners by providing a list with all the visits attended by a patient, in order to allow run-time consulting of the patient medical history.

We included in our EMR system the results of standard evaluation scales (Fig. 2), like the modified Total Lesion Symptom Score (mTLSS) and the Physician Global Assessment (PGA) [10]. We implemented the EMR as a web application based on Apache web Server, PHP pages and MySQL database.

As the aim of the dataset collection was to explicit the underlying process and mine for diagnostic reasoning adopted, through data analysis we created a set of associations and rules able to suggest not only the possible diagnosis given an information dataset, but also the next possible diagnostic step (e.g., a test to be prescribed to reach a diagnosis, or a symptom to monitor). To do so, data
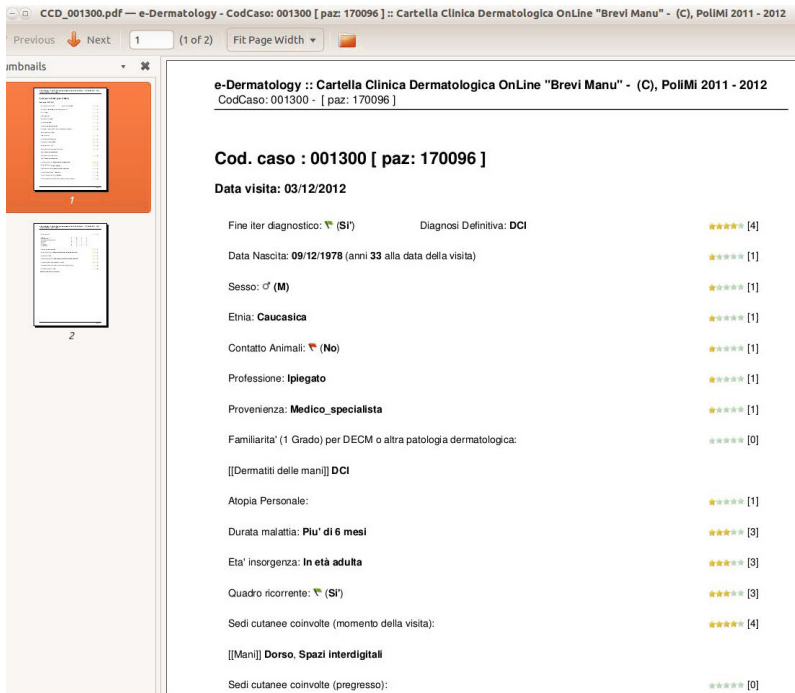
Fig. 3. The stored *EMR* record as a *PDF* file. It is available for reviews by GP, in case of new visits.

analysis used the additional inputs (the 0-5 scores) both to verify the rules and associations identified, and to formulate specific rules.

4   Results

4.1   The Electronic Medical Record [*EMR*] Developed

We developed a specialized EMR system able to collect in a distributed, secure and authenticated way the data about patient's visits from 16 reference centers for hand skin diseases in Italy.

The EMR system is divided in 5 different sections:

– personal information [2]
– demographical information
– physiological conditions
– pathological conditions
– contact reaction tests *[optional]*

---

[2] The identification of the patient is achieved through an ID assigned by the center, and its association with the name is managed outside this system, in every single diagnostic center. In this way we guarantee a strong separation between medical data and personal identification ones.

After the access by protected protocol to the website using the authentication codes provided, each center can manage its own patients, inserting a new visit, retrieving the ones already executed, or inserting an update for an already enrolled patient.

The EMR comprises relevant patient's personal data and an assessment of signs, symptoms and laboratory tests results together with a 5 star-based score of the importance of each single information for the current diagnostic process. In the EMR, the diagnosis field could be labeled as definitive or as temporary. This means requiring more exams or waiting for new signs/symptoms to raise.

To guarantee a secure identification of the patient, the system requires to insert the patients code twice for crosschecking. If the codes inserted are different, an alert will be generated and the two fields (mandatory for the saving of the record inside the system) are deleted. On the other side, if the patient code already exists, the persistent information (such as birth date, residence, gender) will be preloaded in the form, making the filling out of new visit report form quicker.

At the end of the process, the doctor can save or print a PDF compact version - Fig. 3 - of the medical record for the local archive. These files are also optimized for being printed on paper in gray tones. For example, the standard scales are reported in a text format (Fig. 4), the chosen level for each sub-index is highlighted with bold characters and the * symbols (e.g., **1***), while the assessed importance (the number of stars) is clearly reported [5].

4.2   The DataSet

We collected data regarding more than 1.300 visits. More than the 85% were usable for the subsequent analyses, while the others were affected by errors in the data stored and therefore excluded. Table 1 presents the distribution of the diagnoses, grouped as temporary diagnosis requiring further visits (28%), and final diagnosis (72%). The column *AVG(Stars)* shows the average values for the assessed importance (as number of stars) given by the specialists. They are aggregated in two sets, the first, for the attributes filled out for all cases (labeled as *Mand.*, for mandatory) and the second, for the attributes that make sense only for the differential diagnoses of the contact dermatitis (labeled as *Opt.*, for optional).

4.3   The Decision Support System [DSS]

The final objective of this data collection and the following analyses is the development of a Decision Support System for the diagnosis of hand skin diseases devoted to inexperienced GPs. It can be made available to them as a web accessible service or as a stand-alone application, distributed on a portable device, such as USB memory stick, for example. The possibility to store the output of

Table 1. Distribution of the diagnoses in the raw dataset

Diagnosis	—Records—		— Type —		—AVG(Stars)—	
	Nr.	Perc.	Final	Nr.	Mand.	Opt.
Contact Allergic Dermatitis *[DAC]*	248	18.18 %	0	100	2.24	0.61
			1	148	1.71	0.97
Irritant Contact Dermatitis *[DCI]*	207	15.18 %	0	65	2.29	0.19
			1	142	1.89	0.48
Psoriasis *[other]*	205	15.03 %	0	34	2.03	0.20
			1	171	2.34	0.06
Vescicular eczema	175	12.83 %	0	37	2.34	0.11
			1	138	2.47	0.24
DAC+DCI	173	12.68 %	0	40	2.25	0.28
			1	133	1.76	0.92
Atopic eczema	107	7.84 %	0	21	2.62	0.02
			1	86	2.25	0.27
Hyperkeratotic eczema	92	6.74 %	0	28	2.44	0.07
			1	64	2.09	0.23
Atopic eczema + DCI	84	6.16 %	0	20	2.37	0.19
			1	64	2.31	0.79
Nummular eczema	25	1.83 %	0	14	2.54	0.02
			1	11	2.27	0.47
Palmoplantar keratoderma *[other]*	9	0.66 %	0	0	–	–
			1	9	1.27	0.18
Superficial cutaneous mycoses *[other]*	8	0.59 %	0	0	–	–
			1	8	2.31	0.10
Continuous acrodermatitis *[other]*	4	0.29 %	0	1	1.65	0.00
			1	3	1.92	0.00
Pityriasis rubra pilaris *[other]*	2	0.15 %	0	0	–	–
			1	2	0.98	0.00
[[EMPTY]]	*25*	*1.83 %*	0	16	1.28	0.09
			1	9	2.20	0.31
Total	1363	100,00%				

each visit as a PDF file – compacted in a double-sided A4 sheet, through op-
timized data representation, see Fig. 3 – could be a further advantage of the
system. This allows the GP to create a personal and portable digital archive,
and to provide a physical copy of the visit report to the patient (fulfilling local
regulations).

The software will be just a prototype for research purposes and its user inter-
face will initially be only available in Italian. It is expected to be localized easily,
when needed. As far as the USB memory stick is concerned, it can be internally
based on an Apache web server and a MySQL database, accessed using a web
browser, reusing the developed user interface.

Possible Ideas for the DSS. This tool consists of the EMR empowered by
two functionalities:

Fig. 4. A detail of the stored *EMR* record. On the top, the compact representation of *mTLSS* and *PGA* scales.
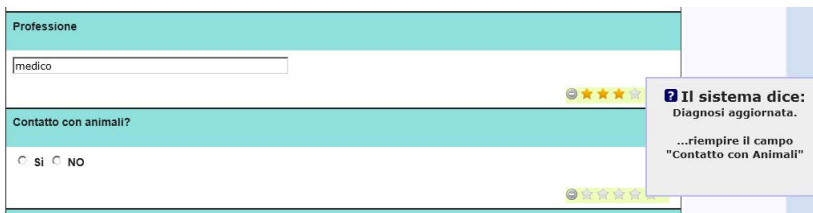

Fig. 5. The final DSS thought: suggestion box filled with an indication *[MOCKUP]*

– The *Suggestion box*. It suggests which attribute should be filled-out, based on the information just provided to the current EMR. In the Fig. 5, the system suggests to fill out the attribute contact with animals.
– The *Rank of Diagnoses*. The probability of each diagnosis is expressed as a percentage (Fig. 6). Only a set probability are shown, but not reordering or hiding are provided, to enforce the idea that the real choice is performed by the – human – medical professional. In fact, the percentages are indicative values from the data extracted, based on statistical and computational methods, such as frequency and co-occurrences, in accordance with experiences in other fields [11].

Fig. 6. The final DSS thought: suggestion on the probability for each pathology [MOCKUP]

5 Conclusions

The system we created provides evidence that tracking the implicit information as used by specialists during the diagnostic process allows to obtain relationships and rules supporting inexperienced GPs in the autonomous primary management of hand skin diseases.

The software application created works as a stand-alone service from a USB memory stick, allowing the GP to bring it with him *anywhere anytime*.

At the moment when this article is being written, we are starting validating the identified rules, with the support of all the specialists included in the panel of '*Ambulatorio della Mano*". The next steps will be the distribution of the developed DSS – on USB memory stick – to a group of the GPs of the Italian public National Health System.

After that, we expect to ask them to fill-out an online questionnaire regarding the different aspects of the system: from usability issues to the perceived usefulness in the everyday diagnostic practices. We also planned to recollect back the information stored in some of the distributed memory sticks, after proper anonymization procedure. We may then analyze and check if the rules found in the initial phase are confirmed by more data on one side and to explore the real usage in the daily practices on the other one.

References

1. Kassirer, J.P.: Teaching clinical reasoning: case-based and coached. Acad. Med. 85(7), 1118–1124 (2010); PubMed PMID: 20603909
2. Svensson, A., Lindberg, M., Meding, B., Sundberg, K., Stenberg, B.: Self-reported hand eczema: symptom-based reports do not increase the validity of diagnosis. British Journal of Dermatology 147, 281–284 (2002), doi:10.1046/j.1365-2133.2002.04799.x
3. Weisshaar, E., Kallen, U., Weiss, M.: 'The itching hand"- important differential diagnoses and treatment. J. Dtsch. Dermatol. Ges. 11(1), 31–42 (2013), doi:10.1111/j.1610-0387.2012.08002.x.
4. Jackson, S., Nesbitt, L.T.: Differential Diagnosis for the Dermatologist. Springer (2012) ISBN: 9783642280061
5. Pesut, D.J., Herman, J.: Metacognitive Skills in Diagnostic Reasoning: Making the Implicit Explicit. International Journal of Nursing Terminologies and Classifications 3, 148–154 (1992), doi:10.1111/j.1744-618X.1992.tb00530.x
6. Krause, P., Fox, J., O'Neil, M., Glowinski, A.: Can we formally specify a medical decision support system? IEEE Expert 8(3), 56–61 (1993), doi:10.1109/64.215223
7. Pandey, B., Mishra, R.B.: Knowledge and intelligent computing system in medicine. Comput. Biol. Med. 39(3), 215–230 (2009), doi:10.1016/j.compbiomed.2008.12.008
8. Davidson, E., Chiasson, M.: Contextual influences on technology use mediation: a comparative analysis of electronic medical record systems. Eur. J. Inf. Syst. 14, 6–18 (2005), doi:10.1057/palgrave.ejis.3000518
9. Ayala, F., Nino, M., Fabbrocini, G., Panariello, L., Balato, N., Foti, C., Tosti, A., Corazza, M., Valsecchi, R.H., Gola, M., Gallo, R., Guarneri, F., Pigatto, P.D., Cristaudo, A., Schena, D., Musumeci, M.L., Stingeni, L., Lisi, P.: Quality of life and contact dermatitis: a disease-specific questionnaire. Dermatitis 21(2), 84–90 (2010); PubMed PMID: 20233546
10. Weistenhöfer, W., Baumeister, T., Drexler, H., Kütting, B.: An Overview of Skin Scores Used for Quantifying Hand Eczema: A Critical Update According to the Criteria of Evidence-based Medicine. The British Journal of Dermatology 162(2), 239–250 (2010)
11. Eynard, D., Mazzola, L., Dattolo, A.: Exploiting tag similarities to discover synonyms and homonyms in folksonomies. In: Software: Practice and Experience. John Wiley & Sons, Ltd. (2012), doi: 10.1002/spe.2150