

# Explicit Tracking in the Diagnostic Process for Hand Dermatological Practices

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**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 practices 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 practitioner with suggestions 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

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\*\* 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 Carità, Novara; P. Calzavara-Pinton, Spedali Civili di Brescia; S. Calvieri, La Sapienza Università, Roma; M. Congedo, Ospedale Vito Fazzi, Lecce; A. Cristaudo, Istituto Dermatologico San Gallicano IRCCS, Roma; C. Crosti, Università degli Studi di Milano; F. Cusano, Ospedale Rummo, Benevento; M. Gola, Università degli Studi di Firenze; P. Lisi, Università degli Studi di Perugia; P. Patrone, Azienda Ospedaliero-Universitaria, S. Maria della Misericordia, Udine; C. Potenza, Polo Pontino, La Sapienza Università, Roma; M. Travaglini, Ospedale A. Perrino, Brindisi.

The screenshot shows a web-based form for medical diagnosis. At the top, there is a navigation bar with tabs labeled 'Pag. 1' through 'Pag. 7' and a 'Salva' button. The main content area is divided into three sections, each with a light blue header and a white body.

- Section 1: Familiarità (1° Grado) per DECM o altra patologia dermatologica**  
 Subtitle: Scegliere una o più delle seguenti voci  
 Left column:
  - DAC
  - DCI
  - Eczema atopico
  - Eczema Vesicolare
  - Eczema ipercheratosico
  - Eczema nummulare
  - Orticaria da Contatto
 Right column:
  - Psoriasi
  - Acrodermatite continua
  - Micosi cutanea superficiale
  - Cherodermia palmo-plantare
  - Pitiriasi rubra pilare
  - Disidrosi
  - Altro:
- Section 2: Atopia Personale**  
 Subtitle: Scegliere solo una delle seguenti voci  
 Options:
  - Eczema atopico
  - Rinocongiuntivite
  - Asma
  - Nessuna risposta
- Section 3: Durata della Malattia**  
 Subtitle: Scegliere solo una delle seguenti voci  
 Options:
  - Meno di 6 mesi
  - Più di 6 mesi

Each section includes a star rating system (5 stars) and a 'abbastanza' label in the bottom right corner.

**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) Vesicular 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<sup>1</sup>.

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

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<sup>1</sup> 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.

**mTLSS (modified Total Lesion Symptom Score)**

	0	1	2	3
Eritema	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Desquamazione	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Lichenificazione/percheratosi	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Vescicole	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Edema	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Fissurazioni	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Puntito/Dolore	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
<b>Punteggio TOTALE: 11</b>				

SCALA mTLSS – modified Total Lesion Symptom Score	
Parametro	Descrizione dell'entità
<b>ERITEMA</b>	0 Assente 1 lieve eritema 2 eritema rosso 3 eritema rosso 4 eritema rosso
<b>SCUAME</b>	0 Assente 1 leggero sfaldamento di zone limitate, per lo più squame sottili 2 sfaldamento di zone più estese, squame più spesse 3 desquamazione di oltre il 30% della mano, con squame spesse e fitte
<b>LICHENIFICAZIONE/PERCHERATOSI</b>	0 Assente 1 lieve ispessimento, con rughe marcate, di zone limitate 2 ispessimento papilloso su aree limitate 3 severo ispessimento su aree estese
<b>VESICIOLE</b>	0 Assente 1 vescicole sparse sul 10% massimo della superficie della mano, assenza di erosioni 2 vescicole sparse e raggruppate sul 30% massimo della superficie della mano, senza visible erosioni e escorrazioni 3 molte vescicole su almeno aree della mano, presenza di erosioni ed escorrazioni
<b>EDEMA</b>	0 Assente 1 gonfiore del dorso o meno del 10% della superficie della mano 2 gonfiore del dorso su più di 10% della superficie della mano 3 gonfiore del dorso e ispessimento della pelle su aree estese
<b>FISSURAZIONI</b>	0 Assente 1 squame scolorite su zone limitate 2 squame scolorite su almeno zone della mano, dolore 3 squame o più fissurazioni profonde, dolore acuto e sanguinamento
<b>PUNTI/DOLORE</b>	0 Assente 1 sfregio occasionale e leggero anche solo nell'arco della giornata 2 sfregio moderato che interferisce nell'arco della giornata 3 dolore persistente e interferisce col sonno

★ ★ ★ ★ ★

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**PGA (Physician's Global Assessment)**  
 Scegliere solo una delle seguenti voci:

Severa o molto severa  
  
 Moderata  
  
 Lieve  
  
 Quasi assente

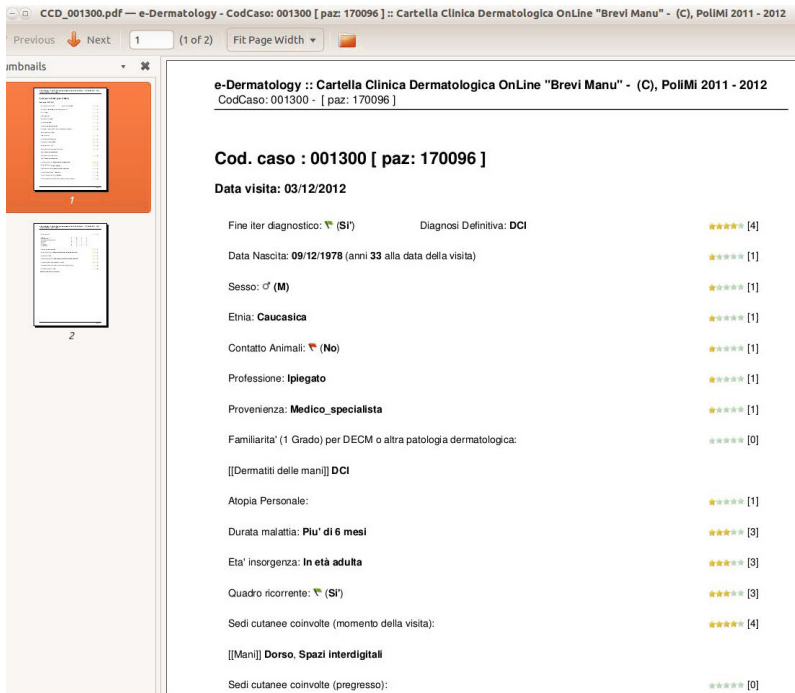
Severità della PCA	Caratteristiche	Intensità	Area interessata*
<b>Malattia severa o molto severa</b>	Eritema, Squame, Ipercheratosi/Lichenizzazione Vescicole, Edema, Fissurazioni, Puntito/Dolore	Alterno una moderata, severa o molto severa	>25% della superficie della mani
<b>Malattia moderata</b>	Eritema, Squame, Ipercheratosi/Lichenizzazione Vescicole, Edema, Fissurazioni, Puntito/Dolore	Alterno una lieve o moderata	10% -25% della superficie della mani
<b>Malattia lieve</b>	Eritema, Squame, Ipercheratosi/Lichenizzazione Vescicole, Edema, Fissurazioni, Puntito/Dolore	Alterno una lieve	<10% della superficie della mani
<b>Malattia quasi assente</b>	Eritema, Squame, Ipercheratosi/Lichenizzazione Vescicole, Edema, Fissurazioni, Puntito/Dolore	Assente	<10% della superficie della mani
<b>Malattia assente</b>	Eritema, Squame, Ipercheratosi/Lichenizzazione	Assente	Non rilevabile

**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 <sup>2</sup>
- demographical information
- physiological conditions
- pathological conditions
- contact reaction tests [*optional*]

<sup>2</sup> 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
Vesicular 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
<i>Total</i>	1363	100,00%				

each visit as a PDF file – compacted in a double-sided A4 sheet, through optimized 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 interface 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:

e-Dermatology :: Cartella Clinica Dermatologica OnLine "Brevi Manu" - (C), PoliMI 2011 - 2012  
 CodCaso: 001300 - [ paz: 170096 ]

mTLSS: totale = 5				★★★★★ [3]	
Eritema	0	*1*	2	3	
Desquamazione	0	*1*	2	3	
Lichenificazione/Ipcheratosi	0	*1*	2	3	
Vescicole	*0*	1	2	3	
Edema	0	*1*	2	3	
Fissurazioni	*0*	1	2	3	
Prurito/Dolore	0	*1*	2	3	
PGA: Malattia <b>Quasi assente</b>				★★★★★ [3]	
Quadro clinico corrente: <b>Eritemato-desquamativo, Eritemato-edematoso</b>				★★★★★ [4]	
Simmetricita': 🚩 (No)				★★★★★ [3]	
Quadro clinico pregresso: <b>Eritemato-desquamativo, Eritemato-edematoso</b>				★★★★★ [3]	
Evoluzione quadro clinico: <b>Cronica (&gt; 6 mesi)</b>				★★★★★ [4]	
Fattori implicati: <i>Nessuna informazione sui fattori implicati dichiarati</i>				★★★★★ [0]	
Dermatite da contatto: 🚩 (No)				★★★★★ [0]	

**Cartella inserita il 2012-12-03 09:23:39**

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

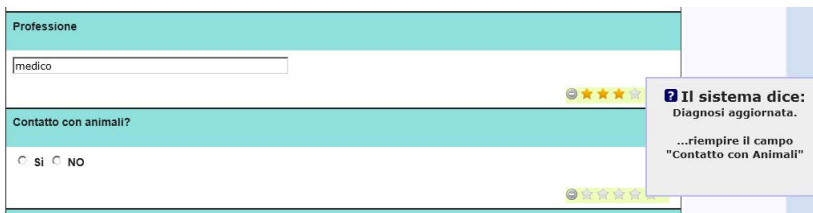


Fig. 5. The final DSS thought: suggestion box filled with an indication [MOCKUP]

- 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].



Si    No

**Diagnosi Definitiva**  
Scegliere solo una delle seguenti voci ?

[[Dermatiti delle mani]]	[[Altre Patologie]]
<input type="radio"/> DAC 18.417%	<input type="radio"/> Psoriasi 15.237%
<input type="radio"/> DCI 15.385%	<input type="radio"/> Pitiriasi rubra pilare 0.222%
<input type="radio"/> DAC+DCI 12.87%	<input type="radio"/> Micosi cutanea superficiale 0.666%
<input type="radio"/> Eczema atopico 7.988%	<input type="radio"/> Cheratoderma palmo-plantare 0.74%
<input type="radio"/> Eczema atopico + DCI 6.287%	<input type="radio"/> Acrodermatite continua 0.37%
<input type="radio"/> Eczema vescicolare 13.018%	
<input type="radio"/> Eczema ipercheriotosico 6.879%	
<input type="radio"/> Eczema nummulare 1.923%	

**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.

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