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Terminology in Written Medical Reports: A Proposal of Text Enrichment to Favour its Comprehension by the Patient

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Abstract

The empowerment of the population and the democratisation of information regarding healthcare have revealed that there is a communication gap between health professionals and patients. The latter are constantly receiving more and more written information about their healthcare visits and treatments, but that does not mean they understand it. In this paper we focus on the patient's lack of comprehension of medical reports. After linguistically characterising the medical report, we present the results of a survey that showed that patients have serious comprehension difficulties concerning the medical reports they receive, specifically problems regarding the medical terminology used in these texts, specifically in Spanish and Catalan. To favour the understanding of medical reports, we propose an automatic text enrichment strategy that generates linguistically and cognitively enriched medical reports which are more comprehensible to the patient, and which focus on the parts of the medical report that most interest the patient: the diagnosis and treatment sections.

Keywords: medical terminology, medical report, terminology, automatic text enrichment, text comprehension, doctor-patient communication.

1. Introduction

When we talk about written communication between doctor-patient, we refer to all the written information handed over during a person's healthcare practice and which is included in his or her clinical history. Within all this written information, the medical report constitutes a key element for the patient, since it contains the diagnosis and the prescribed treatment (Delàs, 2005; Falcón and Basagoti, 2012). A medical report is a written document issued by a medical professional regarding a specific healthcare procedure undergone by a patient —for example, a visit to the accident and emergency department or a hospital admission.

Starting from a linguistic analysis of a corpus of 50 medical reports of patients affected by a rare disease in Spanish and Catalan (CORPUS-ER)[1], we have established a set of linguistic parameters which characterise this type of texts and which might interfere, if not used properly, the reader's full comprehension of the medical report. These parameters, of different linguistic nature, have been grouped in different categories: (a) pragmatic-semantic; (b) syntactic; (c) **lexical**[2]; and (d) orthotypographical. Each one of these major categories has been broken down into several specific parameters. For example, within the lexicon parameter, we have considered the use of acronyms, terms with Greco-Latin formants and symbols, among others.

Moreover, lexically speaking, medical reports have a high number of terms, an excessive use of **non-expanded acronyms**, **abbreviations** and **symbols**, and a high occurrence of **semantically non-transparent terms**.

2. What is a Medical Term?

Terminological units or terms are lexical units of a given language which in a determined communicative context activate a very precise specialised property (Cabré, 1999). Words with specialised content in the medical context (e.g. traditionally referred to as medical terms) activate a precise, concise and appropriate specialised sense that enables us to talk about health and illness related topics in a proper way.

Some of these terms are well known, for example the ones we experience first-hand (e.g. *lung*, *eye*, *flu*, *menstruation*, *muscle*); others, although not strange and apparently semantically transparent, are not easy to define without previous biomedical knowledge since the can be more abstract or polysemous (e.g. *gene*, *symptom*, *treatment*, *cholesterol*, *cancer*, *stem cell*); while many others are extremely opaque for a non-expert from the point of view of their meaning (e.g. *acromegaly*, *Lowe's syndrome*, *CT scan*, *PET scan*, *ALS*, *perimetrosalpingitis*, *lobectomy*).

Traditionally, terms used in medical texts in Spanish and Catalan are mostly formed by lexical bases from ancient Greek and Latin (Bonavalot, 1978; López Piñero and Terrada Ferrandis, 1990; Bernabeu-Mestre et al., 1995; Gutiérrez Rodilla, 1998; Wulff, 2004; Anderson, 2016); but at present, medical terminology is also influenced by languages such as German or French, but mainly by English. Thus, words like, *buffer*, *bypass*, *core*, *distress*, *doping*, *feed-flush*, *flapping tremor*, *follow-up*, *handicap*, *lamping*, *mapping*, *odds ratio*, *output*, *patch test*, *pool*, *relax*, *scanner*, *score*, or *screening* (Navarro, 2001; García Palacios, 2004) are just a small sample of the large number of terms that come directly from English into Spanish.

At the same time there is the belief that the medical terminology is precise, concise, objective and even neutral, as recommended by Terminology ISO standards and many manuals and studies on medical terminology (Bello, 2016; Navarro, 2016; Delàs, 2005). However, from different perspectives it has been found that such a belief cannot be true, as language is significantly complex and communicative situations in medicine are very diverse. It must be remembered that medical terminology is not only used by medical professionals, but also by the entire population —primarily patients and their families— in order to express opinions, fears, concerns and doubts related to their health and illness.

[1] The complete analysis can be found in R. Estopà (Coord.) (2020), *Los informes médicos: estrategias lingüísticas para favorecer su comprensión*

[2] In this paper we will focus only in the lexical analysis since we are interested in showing the results regarding the terminology used in medical reports.

In linguistics, terminological units are lexical units which belong to the lexicon of a language. And the lexicon of any language is exponentially complex and almost never complies with the attributes that are presupposed for the scientific lexicon: neutrality, objectivity, monosemy (Navarro, 2016). It is true, however, that there are some terms that we could label as univocal, descriptive and neutral, such as *poliomyelitis*, which has a "unique" meaning, since it represents a concept in its totality and corresponds to an object "constructed" from reality in a specific conceptual structure (that of medicine). But it is evident that on many occasions medical terms are polysemous (for example, the acronym *AA* is used to refer to *acute abdomen*, but also to *amino acid*, *abdominal appendicitis*, *ascending aorta* and *abdominal aorta*); and they also might variate, in other words, have synonyms (for example, a *stroke* is also known as a *brain attack*, a *cerebrovascular accident*, a *cerebrovascular insult*, a *cerebral vascular accident*, a *haemorrhagic stroke*, an *ischemic stroke*, etc.; and it is also referred to with acronyms such as: *CVA* or *CVI*).

This diversity of designations and diversity of senses, in the case of polysemy, results in confusion amongst specialists and in uncertainty amongst patients. For which uncertainty intermingles with the emotional burden that comes with dealing with a disease (García Palacios, 2004). Ultimately, as Wermuth and Verplaetse (2018, pp. 87) summarize: "Although classical terms still represent the foundation of medical terminology, also words from general language, abbreviations and acronyms, eponyms, slang and jargon words, synonyms, metaphors and metonyms, and made-up words are substantial parts of today's medical language". And, as part of medical language, medical reports also include all these types of units.

3. Use of Terms in Medical Reports

Medical reports record the diagnosis, or the therapeutic procedures carried out during any healthcare visit. This type of text has very particular linguistic characteristics which, taken as a whole, make it difficult to be fully understood. Currently, medical reports are mainly expository documents (Estopà and Domènech-Bagaria, 2018). This means that nominalisation in them is very high and, therefore, there are not so many verbs; consequently, the presence of terminology[3] is very high.

Some surveys conducted on patients (Estopà and Domènech-Bagaria, 2018) and on doctors (Navarro, 2016) show that terminology is one of the main obstacles to fully understand a medical report. Moreover, according to the results of the analysis carried out by Estopà and Montané (2020), terminology comprehension obstacles of a medical report can be summarised in the next four parameters:

1. **Specialised knowledge accumulation**: the number of terms contained in medical reports is very high in relation to the average number of words the text has.
2. **Semantic opacity**: terms are often not known by patients, so they are not semantically transparent.
3. **Semantic confusion**: medical terms can lead to misunderstandings as regards their meaning, especially if they correspond to terms of general use that have acquired a specific, specialised sense in medicine and which is, perhaps, different to their general sense.
4. **Semantic ambiguity**: terms variate and are subject to polysemy, which may cause them to be interpreted in different ways, which increase doubt and uncertainty.

According to these authors, these four parameters can be correlated with nine indicators that allow to determine the comprehension difficulty for a patient of a medical report:

A. Total number of terms in a medical report.
B. The percentage of terms relative to all the words in the text.
C. The percentage of abbreviations.
D. The percentage of terms formed by Greek or Latin lexical bases.
E. The percentage of terms of more general use (terms that were included in the general Spanish and Catalan language dictionaries).
F. The percentage of eponyms (terms derived from proper names, usually from scientists' last names, e.g. *Alzheimer's disease*).
G. The percentage of loanwords.
H. The percentage of defined or paraphrased terms (terms where a paraphrase is used in order to explain them).
I. Number of cases of formal terminological variation.

4. Do Patients Understand Terminology in Medical Reports?

In order to demonstrate that terminology detected and analysed in medical reports lead to comprehension problems for the patients, we implemented two different strategies that complemented each other: a general automatic readability test and a comprehension survey.

4.1 Automatic readability tests

Automatic readability tests or readability formulas are tools that indicate if a text is easily readable or not according to quantitative data (e.g. number and length of words, number and length of sentences). There exist different formulas of this nature developed mainly for English texts, formulas such as the *Reading Ease Score* (Flesch, 1948), the *SMOG test* (McLaughlin, 1969), the *Flesch-Kincaid test* (Smith and Kinkaid, 1970) or the *Gunning FOG test* (Gunning, 1952); but some have also been developed for Spanish: the *Fernández-Huerta index* (Fernández Huerta, 1959), the *Szgriszt index* (Szigriszt-Pazos, 1993) or the *INFLESZ tool* (Barrio Cantalejo et al., 2008). Most of these tests or formulas are open access and available online, so we could easily apply them to the medical reports we analysed.

INFLESZ	very difficult	quite difficult	normal	easy
	14.9%	40.4%	36.2%	8.5%

Table 1. INFLESZ test results for the CORPUS-ER

For example, with one of the most recent test developed for Spanish (Table 1), as well as with the remaining tests[4], results showed that medical reports are in general difficult

[3] Terms are prototypically nouns (e.g., *dermatographia*, *dermatitis*, *dermatology*, *dermatologist*, *dermatomycosis*, *dermatome*), since *noun* is the category that, by definition, binds knowledge together in a referential manner.

[4] For all the details and results of these tests you can check the works of Porras-Garzón and Estopà (2019 and 2020).

to read, hence the need to go further and check qualitatively some of the texts was evident in order to know if they were as difficult to read as the automatic tests reported.
Further qualitative comparison showed that preliminary results of the automatic tests were neither reliable nor discriminating, because these tools are not designed to deal with highly specialised texts (high number of medical terms) such as medical reports. Therefore, it was likely that the actual readability level was even more difficult than what the automatic analysis showed.

4.2 Comprehension survey

The second strategy implemented to confirm the results of the tests and to demonstrate there is a real comprehension problem for the users of medical reports, consisted in a survey which was conducted to a set of people (all of them have been patients and some of them currently are or will in the future be patients).

4.2.1 How was the survey done?

The next steps were followed to carry out the comprehension survey:

1. Selection of one of the medical reports from the CORPUS-ER after the qualitative analysis considering the mean of terminological density and extension.
2. Drafting of a linguistically and cognitively enriched version of said report.
3. Preparation of two comprehension surveys, one for each version of the report (original and enriched), with identical structure and similar questions.
4. An in-person implementation of both surveys was carried out with a group of 100 people. The group was divided into two subgroups: in the first stage, survey A was conducted to group 1 and survey B to group 2; and in the second stage, A to 2 and B to 1 (in this way we avoided the problem of participants learning or getting used to the content of the report from one survey to the other).
5. Statistical treatment of the results (paired-sample t-test in the case of lexical-related numerical variables).
6. Analysis of the results.

So, once the linguistic and terminological parameters that cause comprehension problems had been detected and analysed, we selected a real medical report from our corpus and then produced a new version of it in which said problems were addressed, in order to ensure the maximum understanding by the patient. Although some of the changes made during the enrichment process are in line with the recommendations of the so-called *plain language*, or *simplified language* (NARA guide, 2012), we chose to call the new version of the report a *linguistically and cognitively enriched version*, since no information was removed from it and no terms were discarded nor information paragraphs were altered. The steps taken to enrich the report were the following:

1. correction of grammatical errors (e.g., punctuation marks, missing verbs, order of the elements of a sentence) and typographical inadequacies (e.g., font);
2. **including descriptions and paraphrases of ambiguous or highly specialised lexical elements (terms, phraseology)**;
3. construction of simple phrases that match with Catalan and Spanish prototypical sentence structure of SVO (subject, verb, object);
4. **controlling and expanding abbreviations (abbreviations, acronyms, symbols)**; and
5. personalising the text to bring it closer to the patient (explicit subject, personal verbal form).

In this way, we avoided lowering the cognitive load of these texts, while writing specialised information (term related) in a more explicit way, enriching the report, since the main premise was that patients are not usually able to infer from the text the information naturally inferred by health professionals (e.g. not knowing unexpanded abbreviations or semantically opaque terms). Therefore, a medical report enriched from different perspectives (expanding abbreviations, paraphrasing terms, formulating sentences with conjugated verbs and explicit subjects...) allows the healthcare provider to ensure that the text is explicit, prevents the patient from making erroneous inferences, favours an adequate interpretation of the information and a correct understanding of the full text.
Based on these considerations, from both versions of the medical report (the original and the enriched one), two comprehension surveys with an identical structure were prepared which included the following sections:

- General data for control (sex, age, level of education, mother tongue and profession).
- Answering questions related to previous general perceptions about the comprehension of medical reports.
- Reading the corresponding medical report for the survey (original or enriched version).
- Answering different questions intended to measure the perception about the understanding of the read medical report (original and enriched version). Questions such as *If you didn't understand one section of the text, what do you think is the cause? a) Unknown words, b) Known words that I don't fully understand, c) Unknown acronyms and symbols, d) Unfamiliar expressions, e) Other causes, if so, which?*
- Answering questions intended to measure the actual understanding of the read medical report (term related questions included).
- Comparing fragments of the two versions of the report to know explicitly which of the two was better understood and which of the two was preferred by the patient considering that the information was the same.

Once the general survey parameters were applied, it was essential to carry out a pilot measurement survey (Scheaffer et al., 1987; Sampieri et al., 2000) on a small sample of 25 participants to test its functionality. Testing the survey allowed us to verify the parameters and modify them when needed. After the pilot, the survey was conducted to a total of 100 participants of different ages and level of studies. Participants were divided into two groups of 50 and all of them responded both surveys. On a first stage, the original report survey was conducted on one group and the enriched report survey on the other group; on a final stage the opposite was done: each group took the corresponding remaining survey. This allowed us to ensure there was no learning between one survey and the other.

4.2.2 Discussion of the results

The results obtained after both surveys were highly significant and discriminating. For example, in the case of the lexical-related numerical variables a paired-sample t-test was performed in order to establish the significance value for the difference between means (the mean of

comprehension results of the first survey and the mean of the second one), and the p-value was $p < 0.0001$. So, this allowed us to conclude that most of the participants: a) had difficulties in understanding the original version of the medical report —even participants with a higher educational degree—; b) did not have as many difficulties in understanding the enriched version of the medical report— even the participants with a lower educational degree—; and c) understood the enriched version of the report better than the original version.

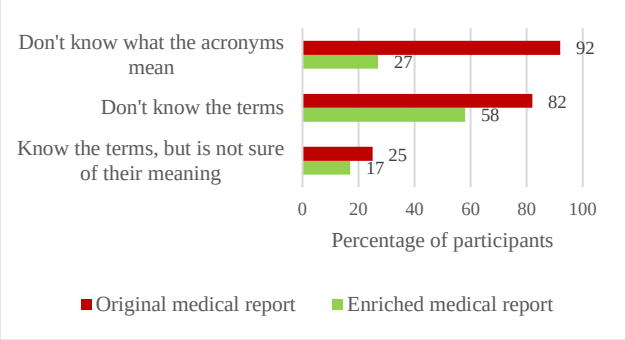

Chart 1: Perception of comprehension of the term related information in the medical reports

The results shown in Chart 1 correspond to the questions intended to measure the patient's perception of comprehension of terms and acronyms within the text. Here participants had to choose what they believed made more difficult to understand the report they just read. We can observe that in general patients perceived the original medical report as more semantically opaque. For example, regarding the unexpanded acronyms, for the original report almost all the participants (92%) selected as a comprehension obstacle the fact that acronyms were not easy to understand, while in the adapted text only 27% of participants felt the same way. Almost the same happens with the perception of unknown terms and, in a lower degree, the perception of barely known terms.

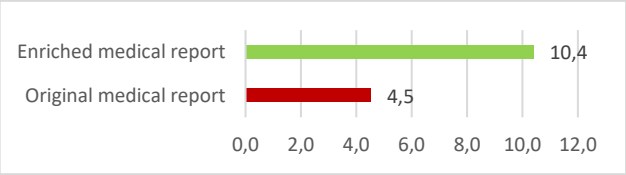

Chart 2: Actual comprehension of the term related questions

In Chart 2 the results regarding the actual comprehension of the term/acronym-related questions (e.g. *what does CBZ refer to?* or *What is nefrocalcinosis?*[5]) are displayed. In order to test/evaluate the participant's comprehension, we scored each answer from 0 to 3 (3 = answers correctly; 2 = answers imprecisely; 1 = doesn't answer or doesn't know; 0 = answers incorrectly [because it is more dangerous for a patient's health to act incorrectly than not to act at all due to not knowing something]). Since there were 4 questions measured, the highest possible result for any participant was 12, and the lowest, 0. So, results in Chart 2 are evidence of the difference of means (which we already said they were highly significant [$p < 0.0001$]) in text comprehension between the original and the enriched version. While after reading the original texts, patients failed the test (4.5 out of 12), after reading the enriched version of the same text, they successfully approved the test (10.4 out of 12).

5. Can we Automatically Enrich Medical Reports?

So far, we have seen that the lack of understanding in medical reports is largely —although not entirely— due to the high concentration of opaque terms and acronyms. Section 4.2.2 demonstrates that actions, like including descriptions or paraphrases of highly specialised lexical elements and expanding abbreviations, can substantially improve the text understanding. However, manually carrying out this lexical enrichment is a time-consuming and labour-intensive task, hence, there is a need to automate linguistic tasks.

In computer science, the process of modifying natural language to reduce its complexity towards improving readability and comprehension is called text simplification (TS) (Shardlow, 2014), and it may involve modifications to the syntax, the lexicon or both.

Starting in the nineties with the first TS application: a grammar checker for Boeing's commercial aircraft manuals (Hoard et al., 1992) there has been much work in TS mainly for the English language. However, since the early 2000s TS started to emerge across different languages and various categories of readers. For example, tools in Japanese (Inui et al., 2003) and Bulgarian (Lozanova et al., 2013) for hearing-impaired people, in French (Max, 2006) and Spanish (Bott and Saggion, 2011) for people with aphasia, in Brazilian Portuguese (Aluísio et al. 2008) for low literacy people, and finally in Italian (Barlacchi and Tonelli, 2013) and French (Brouwers et al., 2014) for schoolchildren or second language learners. Regardless of the language and purpose of simplification tools, there are different methods within the TS field. Systems can use them individually or in combination since they are not mutually exclusive. The most common approaches are lexical, syntactic and explanation generation.

- Lexical approach. Lexical simplification is the task of identifying and replacing complex words with simpler substitutes (Shardlow, 2014). This approach does not attend grammar issues, it only focuses on vocabulary aspects. It also comprises the expanding of abbreviations.
- Syntactic approach. Syntactic simplification is the process of reducing the grammatical complexity of a text, while retaining its information content and meaning (Siddharthan, 2006).
- Explanation generation. Often called semantic simplification, is the process of taking difficult concepts in a text and augment them with extra information. It usually consists of generating an automatic explanation by hierarchically and/or semantically related terms.

Within the medical domain automatic text simplification tools have been developed for different type of texts such

[5] These are real examples of terms used in the analysed medical reports.

as journals articles (Abrahamsson et al., 2014), medical records (Kandula et al., 2010; Zeng-Treitler et al., 2007), information pamphlets (Leroy et al., 2012) and patient information leaflets (Delaere et al., 2009; Segura-Bedmar and Martínez, 2017).

5.1 A prototype for automatic text enrichment

As part of an ongoing doctoral project, we are building an online software so that it will be available from anywhere using a web browser and it will allow to deal with medical reports written in Spanish about rare diseases. It focuses on the sections with the highest concentration of terms: diagnosis and treatment. The strategies to deal with the terminological issues are a) synonym enrichment and b) explanation insertion. To the best of our knowledge, there is no similar tool in Spanish devoted to improving the comprehension of medical reports. Although there are systems for simplifying drug package leaflets (Segura-Bedmar and Martínez, 2017) and to help hearing-impaired people (Bott and Saggion, 2011).

5.1.1 Synonym enrichment

This first task is meant to enrich highly specialised lexical elements by selecting their less specialised versions and **adding them** within the text. It also includes the identification of abbreviations and their expansion into their full form.

For most abbreviations (e.g. *AVC*) their full form will be added (e.g. *AVC - accidente vascular cerebral*), but the patient-friendly abbreviations such as *ADN* will not have their full form (*ácido desoxirribonucleico*) displayed. Patient-friendly abbreviations are manually annotated as *preferred term* within our database.

Our main datasource for abbreviations and their corresponding full forms is the *Diccionario de siglas médicas* (Dictionary of medical abbreviations) from the *Sociedad Española de Documentación Médica* (SEDOM [Spanish Society of Medical Documentation]). Disambiguation of polysemous abbreviations is not yet solved in this first version of the prototype thus, all the associated full forms will be shown.

Regarding the highly specialised lexical elements, we chose the Spanish version of SNOMED CT to map them with a less specialised term.

SNOMED CT is a multilingual structured clinical vocabulary collection of medical terms providing codes, synonyms and definitions (SNOMED, 2017). Our tool searches within SNOMED for synonyms of a highly specialised lexical element and retrieve the patient-friendly term. For example, if the term *hepatomegalia* is found in a medical report, then the tool searches for it in the database and grabs its SNOMED identifier (*80515008* in this case). This identifier serves as a link to other synonyms and therefore, allows to select the best candidate, based on predefined parameters. In the example, *hígado grande* would be the associated element to pick and would be displayed as *hepatomegalia* (*hígado grande*).

5.1.2 Explanation insertion

There are cases where no suitable terms to display are found, then it is necessary to include a short explanation for such terms. For example, the SNOMED identifier 48638002 has associated only one term, *nefrocalcinosis*. The added explanation to the medical report would be *nefrocalcinosis (trastorno en el cual hay demasiado calcio depositado en los riñones)*.

We are currently gathering, analysing and processing explanations for this kind of terms. Since a good comprehension is directly related to the quality of the information provided, we have chosen not to perform automatic explanation generation but to manually review trusted sites (e.g. Spanish version of MedlinePlus website) and adapt the information found. The main parameters we have defined to consider an explanation as valid are the following: information should always come from trusted sources, must be short, dictionary-like, homogenous and with an appropriate level of specialisation.

6. Conclusion

Dealing with any disease represents an emotional burden to patients and this burden increases significantly when they do not understand the medical reports they receive after a healthcare visit. These medical reports have a specific linguistic structure which, from the lexicon point of view, is characterised by an excessive use of medical terms and acronyms which mean for the patient: additional cognitive load, semantic opacity, semantic confusion and semantic ambiguity.

Said comprehension barriers can be breached by cognitively and linguistically enriching the medical report, as has been seen in the results of the surveys. Hence, the ICT and computational techniques to automate text enrichment can be beneficial to doctor-patient communication. Our prototype aims to be used, on one hand, as a support for the healthcare professionals to generate a more patient-friendly document and, on the other, as a query tool for the patients to have a better understanding of what they are reading.

Nevertheless, it is important to note that language is complex, and software may lead to mistakes so computational tools should be used only as an aid. Further work on our proposal might explore different branches like working with syntactic issues, including abbreviation disambiguation to enhance lexical enrichment, or widening the scope of application to other medical reports besides rare diseases.

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