Inclusion of a tag cloud on an electronic health record problems–oriented

Enrique P. Calot[1] and Hernan J. Navas[1,2]

[1] Cloodie SA, Juana Manso 670, 34^{th} floor, A2,
South Tower, Buenos Aires, Argentina,
research@cloodie.com,
WWW home page: http://www.cloodie.com
[2] Independant Consultor

Abstract. The documentation of care events is vital for patient care and is one of the factors that influence the adoption of electronic medical records by a health team. While the traditional registration technique is problem-oriented, it has one limitation: allowing only one relation between problem and a clinical note; which in turn is reflected at the time of retrieving the information associated with each problem. This modelization fails to account that many problems have associated clinical notes and their description or evolutive progress may be related to a different problem. That is why we hypothesized a modification that allows physicians to write first their clinical notes and then associate as many problems as necessary using labels. In turn, to improve interpretation of the problems we create a tag cloud where the most used are larger and vice versa, facilitating the record fetching task in cases where the associated information has labels. As a result of that, we observed that physicians received this modification with satisfaction, flexibility increased when working with morbid patient loads, and the information inside their clinical notes became richer.

Keywords: Electronic Health Record, Problem-Oriented Medical Records, User Experience on Medical Records, Information Storage and Retrieval on Medical Records

1 Introduction

The proper and accurate activity record, as well as the patient's condition, is essential for the health team. The balance between entering information through free text or structured data selection facilitates the adoption of electronic health records (EHR) integrating them with the workflow[**?**]. The most common form of an EHR is problem oriented (POMR, Problem Oriented Medical Record)[**?**]. A coded problem list not only helps physicians detect important features of the patient's health, but it facilitates information systems to identify patients with specific diseases. A complete and updated problem list is the basis for clinical decision support systems (CDSS) and tools for chronic disease management[**?**,**?**]. Usually, EHR have a one-to-one relationship between problems and clinical notes. This generates two limitations:

– The first is related to the information entry order, where professional first selected a problem and then describe their situation in the clinical note. It is likely that describes the situation more of a problem despite having selected just one.
– The second is related to the information retrieval. Some clinical notes associated with a problem detail other problems inside its contents, therefore those problems will be filed under the wrong tag difficulting search features.

Studies have mentioned the possibility of using more of a problem for clinical note to reproduce the clinical thinking we also decided to invert the registration process[**?**]. Professional first writes the clinical note in free text and then create or associated problems as deemed to be representative of the written text; may involve as many as necessary. The problems lists represent a challenge for the physician, and for systems that need this information to assist in making decisions, generating false positives or negatives. There are multiple initiatives to improve those lists[**?**,**?**,**?**]. The problem lists, from another point of view, is similar to the use of tags to categorize information on the Web; where knowledge is created in a collective process. This is one of the reasons we have decided to use the term "tag" instead of "problem" and helps to be more comprehensive and representative. Tags can be represented in a conceptual cloud that is why we decided to add this model to the electronic medical record[**?**]. We adapt some of the existing formulas to the particular health scenario[**?**]. Font size increases on the tag usage frequency; highlighting patient most active problems. Conceptual cloud will allow the physician to focus on the patient-relevant problems. Our goal is to describe how we incorporate the use of tags in clinical notes and their representation in a conceptual cloud.

2 Methods

Cloodie is a company with 9 years of experience in developing computer-oriented health services. Uses free software tools for web-based development. Even though EHR is unique per patient, the system adjusts the information to be shown on its main screen (dashboard) in order to facilitate only relevant information depending on the current environment (emergency, residential or inpatient settings). Shortcut and main action buttons are also displayed on this screen. It is divided into modules, referred as "Chapters" to allow the creation of documents of different classes with the capability of being digitally signed by the author ensuring the inviolability of the record. User experience and usability are two of the main pillars of this development and allow implementing new features with minimal training. Regarding the record format, Cloodie relies on a problem-oriented model due to the frequency other HIS use this method. Nevertheless, we have decided to make a change inverting the process: First, the Physician records the clinical notes in free text and, then selects each problem which is displayed as a related tag. This small change allows the modification of the one-to-one relation between clinical notes and problems changing it to a one-to-many relation

which is more representative. Tags are displayed in a tag-cloud form inside the dashboard to aid the physician showing a general overview of the patient status.

2.1 Tags

Currently, tags are taken directly from ICD-10. After the writing process, the physician uses a tag browser to look up the desired tag. Truncated text search is allowed to facilitate such. It is possible to enter as many tags as the physician thinks considers convenient. Tags may be categorized depending on the asistency level:

- Inpatient / Emergency care:
  - Main problem
  - Secondary problems
  - Main procedures
  - Secondary procedures
  - Comorbidities
  - Personal history
- Outpatient care
  - Consultation reason
  - Comorbidities
  - Personal history

A tag is an alternative way to group all clinical notes linked to it to aid tracing any related problem, with the advantage of having a bigger amount of tag-associated clinical notes. Now, the same clinical note may be found from each tag it possesses. Furthermore, tags may be moved to other categories by any treating professional and may be deactivated to avoid non-relevant visualization. All changes are logged and are available to all professionals.

2.2 Tag clouds

The system provides an innovative way to display problems which is complementary to the classic problem list with categories. In the summary screen, patient care information (dashboard) can be seen in the tag cloud[**?**]. This cloud is a visual representation of the most active problems inside the patient clinical notes. The font size varies proportionally depending on the relevance.

3 Results

The fees for outpatient medical clinical notes chapter was developed allowing the physician to first write the clinical note and then use the search box tags as often as necessary. To avoid unnecessary remain tag cloud, we develop an algorithm to diminish them the size as time passes and these are unused.

3.1 About weight decay

Weights are a form to discriminate relevant from irrelevant or older tags. Our proposed method decays the tag weight over the time in order to make space for tags with newer events. Each tag has the attribute (which may be inherited from its class) mean time (μ) which is the expected time for the event to be relevant. This setting may be adjusted by the institution.

The decay rate follows a negative exponential distribution and –to guarantee that each event has the same relevance– the area below the curve must be 1. Therefore

$$f_{t_0}(t) = \begin{cases} \lambda e^{-\lambda(t-t_0)} & t \geq t_0 \\ 0 & t < t_0 \end{cases} \tag{1}$$

where $\lambda = \frac{1}{\mu}$ and t_0 is the time of the event, must meet

$$\int_{-\infty}^{\infty} f_{t_0}(t)dt = 0 + \int_{t_0}^{\infty} \lambda e^{-\lambda(t-t_0)}dt = \lambda \int_{0}^{\infty} e^{-\lambda t}dt = 1 \tag{2}$$

Each event has a different initial weight depending on the tag that is the inverse of μ which is

$$f_{t_0}(t_0) = \lambda e^{-\lambda(t_0-t_0)} = \lambda e^{0} = \lambda = \frac{1}{\mu} \tag{3}$$

Finally the weight is denoted $\omega_a(t)$ for a specific tag a with mean time ($\mu_a = \lambda_a^{-1}$) and a set of events τ_a each of them ocurring at t_ϵ where $\epsilon \in \tau_a$ at a given time t is

$$\omega_a(t) = \sum_{\forall \epsilon \in \tau_a} f_{t_\epsilon}(t) \tag{4}$$

The modification was carried out in the outpatient setting and initial tests showed satisfaction of users. Tests were performed on the track of a female patient who was pregnant and had influenza. As seen in Figure 1, influenza had a time of much shorter duration than pregnancy because the latter required multiple consultations with their respective clinical note.

For example, the mean time (μ) of influenza is one week and the mean time (μ) of a pregnancy is 40 weeks; let us suppose that events 1 (week 2), 2 (week 4), 3 (week 8) and 4 (week 30) are associated with pregnancy and events 3 (week 8), 5 (week 35) are associated with influenza.

In the case of pregnancy (I)

$$\tau_I = \{\epsilon_1, \epsilon_2, \epsilon_3, \epsilon_4\}, \mu_I = 40wk, \lambda_I = \frac{1}{40}wk^{-1} \tag{5}$$

In the case of influenza (II)

$$\tau_{II} = \{\epsilon_4, \epsilon_5\}, \mu_I = 1wk, \lambda_I = 1wk^{-1} \tag{6}$$

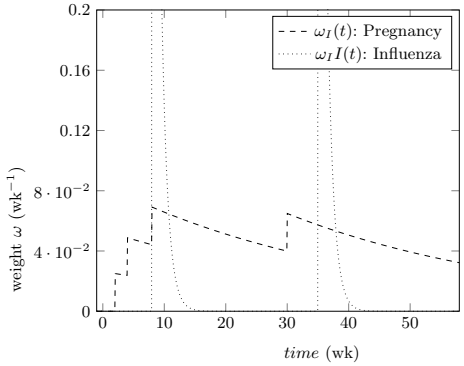

Fig. 1. Weight change over the time. Influenza is more important only a couple of weeks after the events at the 8^{th} and the 35^{th} weeks.

So

$$\omega_I(36wk) = \sum_{\forall \epsilon \in \tau_I} f_{t_\epsilon}(36wk) = \sum_{\forall \epsilon \in \tau_I} \lambda_I e^{-\lambda_I(36wk - t_\epsilon)} \quad (7)$$

$$= \lambda_I \sum_{\forall \epsilon \in \tau_I} e^{-\lambda_I(36wk - t_\epsilon)} \quad (8)$$

$$= \frac{1}{40wk}(e^{-\frac{36wk-2wk}{40wk}} + e^{-\frac{36wk-4wk}{40wk}} + e^{-\frac{36wk-8wk}{40wk}} + e^{-\frac{36wk-30wk}{40wk}}) \quad (9)$$

$$= \frac{1}{40}(e^{-\frac{34}{40}} + e^{-\frac{32}{40}} + e^{-\frac{28}{40}} + e^{-\frac{6}{40}})wk^{-1} \approx 0.05585wk^{-1} \quad (10)$$

In the case of the influenza,

$$\omega_{II}(36wk) = \lambda_{II} \sum_{\forall \epsilon \in \tau_{II}} e^{-\lambda_{II}(36wk - t_\epsilon)} \quad (11)$$

$$= \frac{1}{1wk}\left(e^{-\frac{36wk-8wk}{1wk}} + e^{-\frac{36wk-35wk}{1wk}}\right) \quad (12)$$

$$= (e^{-28} + e^{-1})wk^{-1} \approx 0.36788wk^{-1} \quad (13)$$

After calculating the weights for all events that had been associated with the EMR, the list is sorted by weight and a normalization adjusts proportionally each weight with a desired font size to create a tag cloud

$$fontSize_a(t) = \min(fontSize) + (\omega_a(t) - \min(\omega)) \frac{\max(fontSize) - \min(fontSize)}{\max(\omega) - \min(\omega)} \quad (14)$$

4 Discussion

The use of ICD-10 conditions the use of tags for the limitations of classification. We built this version instead of the 9-CM version by the inclusion of signs and

symptoms. We are planning to incorporate short-term synonyms that expand vocabulary and abbreviations used belonging to the local lingo. This strategy will cover an even larger list of terms and maintain the logic of development. Moreover, in the long term we are planning to incorporate terminology services[**?**]. These services allow us to handle a wider and adapted to local needs vocabulary interface; and tests with several existing classifications as ICPC-2, ICD-10, etc. Once all office professionals have adapted to the use of this system and we obtain a representative feedback, we will complete the development in the missing areas. While the algorithms to reduce the size of the labels have proven very useful in testing environments, it is necessary that we collect patient information for a long time and consult with the treating physicians to assess whether the algorithm remains accurate and functional.

5 Conclusion

We observed that physicians have received this modification with satisfaction as it gives them flexibility when working with morbid patient load and the information related to their progress clinical notes. The ability to display only the most active problems by a tag cloud represents a saving of time to the physician because it prevents the professional should read endless lists of problems where the majority no longer generates any consultation or medical opinion. We would like to assess how the ability to retrieve relevant information was improved by using labels but will need time go. We believe that this minor modification to the usual registration process to reverse the order and increase the number of problems associated with developments improve the quality of care by providing and accurate decision making relevant information.