of the Creative Commons Attribution Non-Commercial License 4.0 (CC BY-NC 4.0). doi:10.3233/SHTI200553

Guideline-Based Decision Support System for Nursing Homes: A Case Study with the Management of Malnutrition

Abir ABDELLATIF ^{a,b,c,1}, Jacques BOUAUD ^{d,a}, Joël BELMIN ^{e,b} and Brigitte SEROUSSI ^{a,f} ^aSorbonne Université, Université Sorbonne Paris Nord, INSERM, UMR S_1142, LIMICS, Paris, France ^bAP-HP, Hôpital Charles-Foix, Ivry-sur-Seine, France ^cTeranga Software, Paris, France ^dAP-HP, DRCI, Paris, France ^eSorbonne Université, Paris, France ^fAP-HP, Hôpital Tenon, Paris, France

Abstract. Nursing home (NH) residents are known to be at risk of preventable adverse events due to inadequate monitoring or failure to provide necessary treatments. Missed care has been partially explained by nurses' lack of knowledge. We describe a guideline-based decision support system for the management of malnutrition in NHs. Three steps are distinguished: screening, therapeutic management, and follow-up. Clinical practice guidelines have been modeled as decision trees and formalized as IF-THEN rules to be triggered by electronic health records data (e.g., weight, albuminemia). We propose a visualization of recommendations as a dashboard of gauges displaying both current and previous levels of malnutrition to inform on the effect of therapeutic management and facilitate a correct follow-up.

Keywords. Clinical decision support system, clinical practice guidelines, visualization, nursing homes, malnutrition, geriatrics

1. Introduction

As people are living longer, often with chronic conditions and loss of independence in the activities of daily living, an increasing number of older people currently live in nursing homes (NHs). Studies report that NH residents are at risk of adverse events, many of which being classified as preventable due to inadequate monitoring or failure to provide necessary treatments or care plans [1]. Evidence from hospitals has shown that when nurses work with insufficient staff and resources, they are more likely to leave necessary patient care undone [2]. Such missed care in NHs has also been explained by nurses' lack of knowledge, for instance, observed malnutrition rates range from 40 to 90%, despite the existence of clinical practice guidelines (CPGs). The deployment of electronic health records (EHRs) in health care institutions has rapidly

¹ Corresponding Author, Abir Abdellatif, Hôpital Charles-Foix, 7 avenue de la République, 94200 Ivrysur-Seine, France; E-mail: abir.abdellatif@gmail.com.

increased in developed countries. Clinical decision support systems (CDSSs) connected to EHRs have already demonstrated their impact in improving care quality in both hospitals and primary care settings. If recent studies have demonstrated that CDSSs may improve the management of NH residents [3], a scoping review of the literature [4] found that very few CDSSs are currently in routine use in NHs. In order to enrich the NETSoins EHR developed by Téranga Software and widely used in French NHs, we are developing CPG-based CDS modules applied to malnutrition, pressure ulcers, osteoporotic fracture, and drug prescription². This paper focuses on the design of the CDS module that supports the management of malnutrition.

2. Methods

2.1. From textual guidelines to computer-interpretable guidelines

Several CPGs have been published for the management of malnutrition for the elderly. We chose to implement the CPGs developed by the Haute Autorité de Santé (French national agency for healthcare quality) [5]. The first step has been to formalize CPG contents as decision trees that have been translated by a gerontologist as human-readable IF-THEN decision rules validated then by dietitian and geriatrics experts.

2.2. Guideline-based malnutrition management

The management of malnutrition is organized in three steps: malnutrition screening, therapeutic management, and follow-up. If nurses are essentially the targets of malnutrition screening, physicians are also involved in the therapeutic management and follow-up, especially when the symptomatic treatment of malnutrition is not efficient to solve the problem, and when digging deeper into the clinical picture to look for underlying pathologies is necessary. Mainly five criteria are used: weight loss in the last month (WL_1m), weight loss in the last six months (WL_6m), body mass index (BMI), albuminemia (Alb), and Mini Nutritional Assessment score (MNA).

- *Malnutrition screening:* to assess the malnutrition status (MA), weight losses are first explored, then BMI, Alb, and MNA. Three MA levels are used, either no malnutrition, or moderate malnutrition, or severe malnutrition. In the presence of malnutrition (either moderate or severe), dietary intakes have to be assessed (DIA) on a three-day period. Figure 1a displays the corresponding screening decision tree.
- Malnutrition therapeutic management: recommendations on how to manage malnutrition are provided according to the levels of the pair (MA, DIA). Figure 1b displays the therapeutic management decision tree. Malnutrition is modeled as a function of weight loss, albuminemia, and time, MA (WL, Alb, t). In the same way, dietary intakes are varying with time, DIA(t). Both values are recorded over time to assess the longitudinal evolution of malnutrition. Once malnutrition is established (MA=moderate or MA=severe), dietary advices are provided. When MA=severe or when DIA=decreased+, oral nutritional supplements (ONS) or enteral nutrition (EN) should be added. Re-

² This research is funded by Téranga Software and the ANRT CIFRE Grant n° 2018/0307 for AA.

assessment of weight loss, Alb, and DIA have to be performed within a time period T that varies according to the severity of the clinical condition represented by (MA, DIA).

• *Malnutrition follow-up:* (MA, DIA) re-assessment is performed at t+T with T $\in \{T_{1M}, T_{15D}, T_{1W}\}$, along with DIA. At this step, the main criterion is to evaluate whether there has been an increase from DIA(t) to DIA(t+T). In each case, according to the evolution of weight and Alb, CPGs provide recommendations for the management of certain risks and the order of some lab tests, e.g., "Risk of dehydration, monitor blood tests".



Figure 1. Decision trees for malnutrition assessment (left side, 1a) and management (right side, 1b).

2.3. Visualization of recommendations and alerts

Information visualization is defined as the use of visual representations of data, information, or knowledge to help users gain a deeper understanding of a domain's content. The principle is that the right display would reduce the cognitive load of data interpretation. It is especially true with CDSSs to help better detection, interpretation, understanding, and evaluation of patient data for decision-making. Various visualizations of recommendations have been designed such as dashboards [6]. We proposed to implement gauges gathered in dashboards to represent the assessment of a NH resident clinical situation. In the case of malnutrition, the principle is to (i) highlight the current patient MA(t), (ii) remind the previous patient MA(t-T), and (iii) provide recommendations to support the right patient-specific management. Figure 2 illustrates the dashboard visualization included in the NETSoins EHR interface (names, patient data and picture are fake, only provide to display the CDS interface).

3. Results

We have simulated the execution of the system on the case of a 74-year-old patient, with moderate Alzheimer disease. At NH admission in September 2019, weight=72 kg, height=1.80 meter, BMI=22 kg/m2, Alb=35 g/l, and MNA=22. Weight=71 kg on March 8th, 2020, and 65 kg a month later which triggered a malnutrition alert, the display of the gauge indicating a moderate malnutrition, and the request for DIA during three days, which lead to DIA=decreased. Recommendations for dietary advices and to

re-assess the weight loss, Alb, and DIA in 15 days were displayed. On April 23rd, pre-Alb=37 g/l, patient weight=63 kg. MA is severe as displayed by the gauge (in bold in Figure 2 whereas the previous level is displayed in grey). Follow-up recommendations are displayed when sliding the cursor over the gauge.



Figure 2. Dashboard visualization included in the NETSoins EHR interface.

4. Discussion and conclusions

Improving care quality in NHs would require improving the competencies of health professionals. We have developed CDSSs to enrich NETSoins, a NH-specific EHR widely used in France. The CDS modules use the same proprietary terminology as NETSoins to be interoperable with the EHR. Currently, CDS modules for the management of malnutrition and pressure ulcers are being implemented. The applications of the approach to the management of osteoporotic fracture and to support drug prescription are still to come. CDS modules usability and user acceptability have to be evaluated. Focus groups are planned with NH health professionals. The aim is also to test the idea to go for a full dashboard user interface. The clinical impact of such decision support proposal will have to be further assessed.

References

- [1] Thomas EJ, Brennan TA, Incidence and types of preventable adverse events in elderly patients: population based review of medical records, BMJ 320 (2000), 741-744.
- [2] White EM, Aiken LH, McHugh MD, Registered Nurse Burnout, Job Dissatisfaction, and Missed Care in Nursing Homes. J. Am. Geriatr. Soc 67 (2019), 2065-2071.
- [4] Proceedings of the MIE Conference (2020) (To appear).
- [5] https://www.has-sante.fr/upload/docs/application/pdf/denutrition_personne_agee_2007_recommandations.pdf (last access on April 23rd, 2020).
- [6] Lee MT, Lin FC, Chen ST, Hsu WT, Lin S, Chen TS, Lai F, Lee CC, Web-Based Dashboard for the Interactive Visualization and Analysis of National Risk-Standardized Mortality Rates of Sepsis in the US. J Med Syst 44 (2020), 54.