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Challenges of Trustable AI and Added-Value on Health
B. Séroussi et al. (Eds.)

doi:10.3233/SHTI220423

Learning Bayesian Networks for the Prediction of Unfavorable Health Events in Nursing Homes

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Abstract. This study[2] proposes the use of Bayesian Networks for the prediction of unfavorable health events, and more especially pressure ulcers, in nursing homes. From a database of electronic medical records, we learn an explainable and relevant classifier, which performs better than the scores currently used in nursing homes.

Keywords. Machine Learning, Bayesian Networks, Nursing Homes, Explainability

1. Introduction and Methods

With the development of new computer technologies in the healthcare field, a growing number of healthcare institutions use information systems that gather administrative and medical data on patients. NETSoins, edited by Teranga Software, is one of these systems and is used by more than 3 000 nursing homes (NH). The goal is to use anonymous data from this NH residents record software to develop algorithms able to predict several adverse health events that are potentially preventable by appropriate health interventions. As a first step, the prediction is focused on the occurrence of a resident's first pressure ulcer (PU). A PU is a lesion of the skin related to prolonged compression between a bone and the support on which the patient rests. This condition is painful and a source of infection, and it significantly impairs quality of life [1]. PU are however highly preventable with a particular and multidisciplinary approach. Currently, NH staff can use simple clinical tools to identify the residents at risk to develop PU, like the Norton and the Braden scales, but they overlook important risk factors [2]. To develop a better preventive system, we particularly focused on artificial intelligence methods with strong explainability such as Bayesian Networks (BN). A BN is a probabilistic graphical model that represents a set of variables and their conditional dependencies via a directed acyclic graph [3]. BN are often considered as a good compromise between accuracy and explainability. Here, we make the choice to focus on bringing knowledge from a medical point of view (like new risk factors). This also allows the users, carers and medical staff, to have confidence because they can understand the algorithm's decision. In this process,

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[2] This research is funded by Teranga Software and the ANRT CIFRE Grant n°2019/1519 for CC.

we have retrieved information from medical records of more than 100 000 residents free of PU at admission in the facility. Variables with potential interest were determined with expert geriatricians and kept in the analysis based on the completion rate. A training dataset was then set up with the parameters of the residents and two classes were defined: experience the PU or not. An important issue is to take into account the transformation of an event database into data that can be used by statistical learning, while keeping a medical meaning. To elaborate a BN classifier, we learn the structure of the network from estimates on the training base, and then compute the probability of belonging to a class knowing the observations of each variable on an individual. For the evaluation, we compute the F-score. This is the harmonic mean of the precision and sensitivity scores and we want to maximize it. Three distinct datasets with different temporalities objectives are created: a prediction 1 month before the PU episode, 2 and 3 months before.

2. Results

Table 1. Summary tables of the different F-scores according to the methods and prediction timings

F-Score	1-month	2-months	3-months
BN Classifier	0.70	0.69	0,67
Random Forest	0.72	0.69	0.70
Braden Scale	0.32	-	-
Norton Scale	0.29	-	-

The results obtained are available in Table 1. We notice for pyAgrum's BN Classifier [4], that the more the timeline is far away, the more difficult it is to correctly predict the PU. However, the results do not differ much and the benefit for the resident to have an earlier preventive protocol is important. The F-Score of BN Classifier has been compared with that of Random Forest and we found the predictive power was similar. We also calculated the F-score of the Norton and Braden scales and our method has much better results than the methods currently used in NH.

3. Discussion and Conclusions

In this paper, we propose a classification based on BN in a predictive medical context that proves to be efficient in terms of results. It would also be calculated automatically, which is a significant time saving for the caregiver. Many improvements are still possible, in particular in the exploitation of the time series. The intent is that the approach will be put into practice to generate alerts to bring high-risk situations to encourage to implement preventive interventions for the targeted events.

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