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Predicting Preventable Hospitalizations among Elderly Recipients of Home Care

a Study Protocol

Stausholm, Mads Nibe; Secher, Pernille Heyckendorff; Cichosz, Simon Lebech; Hejlesen, Ole

Predicting Preventable Hospitalizations among Elderly Recipients of Home Care: a Study Protocol

Mads N. Stausholm, Pernille H. Secher, Simon L. Cichosz, Ole K. Hejlesen

Department of Health Science and Technology, Aalborg University, Aalborg, Denmark

Abstract

Ageing population and traditional consequences of ageing is expected to cause an increased number of recipients of community care services and socio-economic burden. To accommodate these changes, The Danish Health Authority has recommended several tools to help community personnel detect early signs of disease in the home care setting. These tools are used solely for detecting current deviations from the habitual health status, and no data analysis is performed in order to predict upcoming deviations. This paper describes a study protocol to investigate the potential of developing a data driven decision support model to predict unplanned, preventable hospitalizations. Machine learning techniques, such as logistic regression, will be applied on data from three various sources in order to predict which recipients of home care services are at risk of an unplanned, preventable hospitalization. If successful, the proposed model may facilitate earlier prediction and actions towards deviations from the individual citizen's habitual health status and thereby increase the chance of prevention of hospitalization and functional decline.

Keywords:

Health Services for the Aged, Decision Support Techniques, Forecasting, Hospitalization.

Introduction

The number of recipients of home care services and the socio-economic burden hereof is expected to increase due to the combination of population ageing and traditional consequences of ageing [1]. Rising life expectancy and declining fertility rates are among the main contributors of population ageing. Traditional consequences of normal ageing are decreases in health status, physical function, and quality of life [1], [2], [3]. Such decreases can lead to acute events that may result in unplanned hospitalizations. Hospitalization is associated with long-lasting or even permanent declines in health status and physical function [4], [5]. The aforementioned changes can affect the citizens' ability to conduct simple everyday tasks, such as cleaning their home or managing personal hygiene [1], and thereby cause a need for additional home care services. In Denmark, the home care services are primarily managed by the 98 municipalities, each taking care of its own residents. All 98 municipalities have agreed on a common definition of a preventable hospitalization, which is a hospitalization with one of the following primary diagnoses [6]:

- Nutritional anaemia
- Bone fracture
- Pneumonia
- Acute bronchitis
- Chronic lower respiratory disease
- Pressure ulcer
- Gastroenteritis
- Cystitis

On average, a Danish municipality will have some sort of home care interaction with 22% of its citizens aged 65 or above and 49% of those aged 80 or above [7]. According to [8], 2.4% of the entire Danish population either lives at an elderly care centre or receive home care services. These are responsible of 11.2% of the national health care expenses and the socio-economic burden hereof is expected to rise. The number of citizens aged 65 or above is expected to increase from 1.1 million (2017-level) to 1.6 million by year 2060 [9], and so is the number of care-needing citizens.

During the past few years the focus of detecting early signs of disease exacerbations and preventing unplanned hospitalizations in elderly has increased [10]. Several studies have investigated the risk factors of hospitalizations and prediction hereof and found several biomarkers, malnutrition, high and low BMI, comorbidities, renal insuffiency, polypharmacy, and hospitalization within the preceding year to be predictors of hospitalizations [11], [12], [13], [14].

In 2013, The Danish Health Authority published a report highlighting this problem and provided guidelines to help the community personnel assess and register the citizen's health information, and act upon any abnormalities detected [10]. Specific focus points were development of tools and instructions to further educate community personnel and help them

detect early signs of disease exacerbations and react properly thereto [10]. One of the tools provided to the community
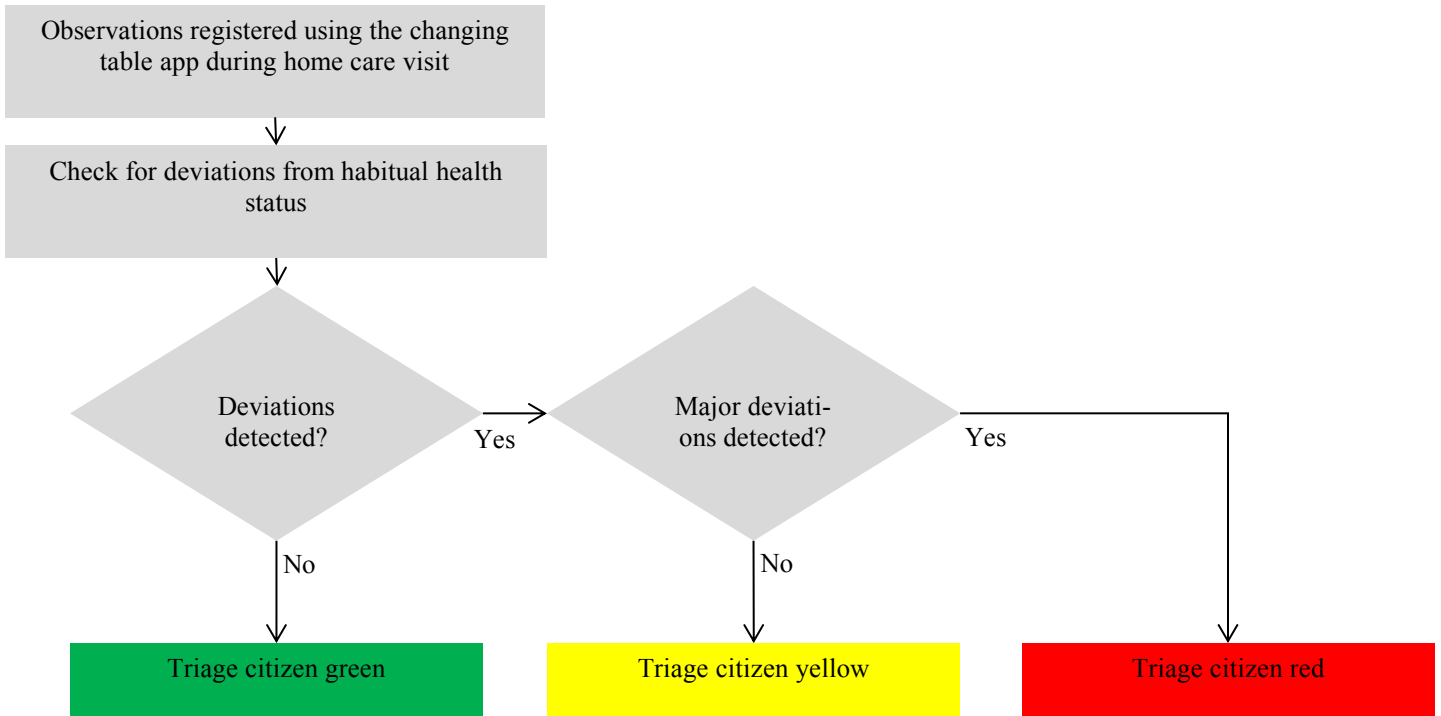

Figure 1 – Overview of the workflow when community personnel observe and register information in the changing table app and how the citizen is triaged based on presence deviations from habitual health status

personnel is the triaged changing table (Danish: Ændringsskema), which is a check-list tool used to detect changes in the citizen's habitual state by answering questions within five subgroups of health status:

- Mental and social state
- Behaviour in the home
- Activities of daily living
- Consumption of food and beverages
- Physical complaints

Figure 1 provides an overview of the workflow using the triaged changing table. The registrations are compared to the citizen's habitual health status and decision support are provided to the community personnel to help deciding if and which further actions are needed. Using these tools results in a much more detailed documentation of the five subgroups of health status of the individual citizen and provides useful information for a decision support system [10]. Based on the report from The Danish Health Authority, Aalborg Municipality implemented a digital version of the triaged changing table in order to minimize the number of preventable hospitalizations. In 2014, Aalborg Municipality provided home care for 7,657 citizens aged 65 or above, which in total experienced 834 preventable hospitalizations [6], [15], [16].

While the aforementioned studies have identified risk factors and predictors of hospitalizations, most of these are not easily obtained in the current home care settings. In the municipality of Aalborg, the community personnel perform routinely registrations during each home care visit. These registrations are used as input in a triage-model, which is designed to detect deviations from habitual health status and provide decision support for further actions. Implementation of the digital triaged changing table provides a systematic approach to identify deviations from the habitual health status and decision support regarding required actions. These tools are used solely for detecting current deviations from the habitual health status, and no data analysis is performed in order to predict upcoming deviations.

The research objective of this study is to investigate whether it is possible to use machine learning techniques to predict unplanned, preventable hospitalizations in elderly recipients of home care services based on demographic, municipal, and regional information combined with routinely collected community personnel registrations.

Materials and Methods

Study Design

This study will be conducted as a retrospective cohort study as historical data is used for investigating the potential in predicting preventable hospitalizations in elderly recipients of home care services. The study will be conducted within the municipality of Aalborg in the North Denmark Region.

Data from the period of 2016-2017 from at least 600 subjects is planned to be included in the study. The results of this study will be published in an international peer-reviewed journal.

Inclusion and Exclusion Criteria

All subjects must have received home care services in Aalborg Municipality at least once a week during 2016 and 2017 and reached the age of 65 as per 1st of January 2016. Furthermore, subjects must have experienced at least one preventable hospitalization during the period of interest. Terminal subjects and subjects with severe mental disorders will be excluded from the study.

Data

The data for this study is planned to be obtained from at least 600 recipients of home care services in the municipality of Aalborg. Data is extracted from three various sources: 1) The electronic home care record (EHCR), which holds both demographic and municipal information, such as past and current home care services, 2) the triaged changing table database where all registrations and triage state changes are stored, and 3) the Danish National Patient Register (DNPR), which holds information of e.g. hospitalizations. Table 1 shows which information variables that will be extracted from each of the three data sources. The data will be extracted as three different data sets and subsequently pooled based on subjects' social security numbers.

Table 1 - Overview of the extracted information from the three data sources

Data source	Information variables
Electronic home care record	Age, sex, gender, civil status, comorbidities, medical prescriptions, past and current home care services including start and stop dates, and cost of home care services
Triaged changing table database	Habitual health status, registrations from each home care visit, and information concerning deviations from the habitual health status
Danish National Patient Register	Previous hospitalizations including primary diagnosis, treatment, length of stay, and cost. Contacts with or services received by other primary care units

Classification

Pre-processing

As the subject is either at risk of an unplanned, preventable hospitalization the problem is considered a binary classification problem. The dataset will consist of demographic, municipal, and regional data as well as data from the triaged changing table database. Continuous municipal, regional, and triaged changing table data registrations will be divided into event and control periods:

- Event periods: Data from a fixed period, e.g. two weeks, leading up to a preventable hospitalization

- Control periods: Data which is not within an event period or immediately following hospital discharge

Control periods will be segmented using a sliding window approach with a window size of similar length as the event periods. Data analysis will reveal the appropriate window size. The number of control periods is expected to be much larger than the one for event periods.

Feature Selection

As shown in Table 1, the feature set will consist of nominal, ordinal, and continuous features from the EHCR, the triaged changing table database, and the Danish National Patient Register. The data will be divided according to the event and control period definitions.

The feature selection will be conducted using MATLAB R2017b by performing a sequence of backwards feature elimination and forward feature selection on the entire feature set. Features will be selected based on the minimization of the misclassification rate and the resulting feature set will be passed into the classification model.

Classification Model

The requirements of the classification model are robustness towards highly imbalanced data (event periods vs. control periods) and handling of various data types, such as nominal, ordinal, and continuous. A logistic regression model complies with the aforementioned requirements and will be the classification model of focus in this study. The logistic regression model returns the probability of the subject being at risk of experiencing a preventable hospitalization or not, which corresponds to the probability of the data sample being from an event or control period, respectively. This is illustrated in Figure 2, which also provides an overview of the model.
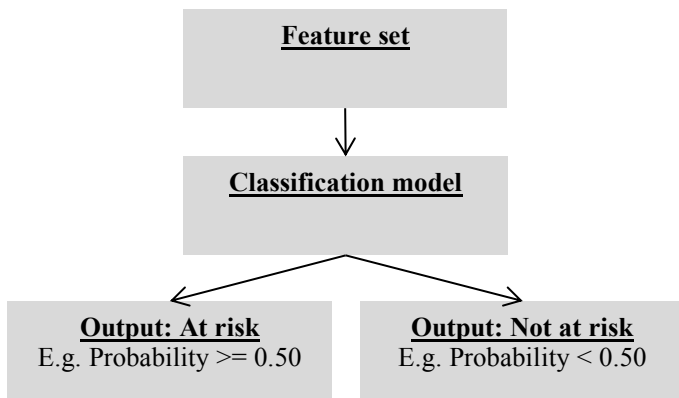
Feature set

↓

Classification model

Output: At risk	**Output: Not at risk**
E.g. Probability >= 0.50	E.g. Probability < 0.50

Figure 2 – Overview of the classification model, which takes a feature set as input and provides a probability of an event as output

Cross validation will be performed in order to account for overfitting and the model performance will be evaluated using the averaged classification accuracy and standard deviation along with a confusion matrix and a receiver operating characteristic curve.

Implications

Reducing the number of unplanned, preventable hospitalizations in recipients of home care services is a national priority in Denmark and is considered a method to accommodate the consequences of population ageing. Currently several tools have been developed for this purpose but to our knowledge no initiatives involves the application of advanced data analytics and data science techniques. By applying such techniques on data that currently is registered continuously it may be possible to predict unplanned events at an earlier stage compared to the current practice. If successful, the proposed model may facilitate earlier actions towards deviations from the individual citizen's habitual health status and thereby increase the chance of preventing hospitalization and functional decline. This may lead to substantial societal gains why the study complies with the EU general data protection regulation.

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Address for correspondence

Mads N. Stausholm, Department of Health Science and Technolo-
gy, Aalborg University, Aalborg, Denmark;

E-mail: mns@hst.aau.dk.