Original Article

Designing an Elderly Hospital Admission Risk Prediction Model in Iran's Hospitals

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Abstract

Background: The identification of elderly at risk of new functional disabilities in activities of daily living at admission to the hospital may facilitate referral for purposive interventions to prevent decline and institutionalization. This study was aimed at designing a risk prediction model for identifying the elderly at risk of admission in Iran's hospitals. **Materials and Methods:** This is a cross-sectional descriptive study conducted in 2017. In order to formulate and validate a prediction model, the study was done in two development and validation cohort study. Functional decline was defined as a decline of at least one point on the Katz ADL index at follow-up compared with preadmission status. **Results:** In development cohort, the mean age was 71 years including 54% of men and 46% women, 22% of men and 17% of women experienced functional decline after 3 months. In the validation cohort, the mean age was 70 years, including 49% of men and 51% women, 19% of men and 15% of women, functional decline after 3 months was observed. **Conclusion:** On the basis of the findings, aging at risk of hospital admission can be identified by easy designed model with four questions: (1) Is the patient's age more than 85 years? (2) Does the patient's mini mental status <22? (3) Does the patient need help for using general transporting? (4) Has the patient lost weight <5% over the past 6 months and body mass index <18.5? And also geriatrics experts can use the designed model as a predictive tool in order to improve the quality level of healthcare services to elderly as a vulnerable and high risk group. The important point of model is easy to use even for nonspecialists.

Keywords: *Admission, aged, hospitals, Iran, risk*

Introduction

In recent years, technological advances have helped many people survive of life-threatening illnesses and more people experience old age. Therefore, maintaining and improving the health services and quality of elderly life as vulnerable people has been taken into consideration more than ever before.[1] Patients over the age of 65 years constitute two-thirds of admissions, 40% of all hospital bed days, and 65% of National Health Service (NHS) budget spend in acute care.[2] The Iranian National Census in 2016 indicated that 6.1% of the population of Iran is more than 65 years old and would reach about 19% by 1030.[3] Considering that in recent years, the issues and problems associated with aging people have been raised as one of the major challenges for policy makers and health planners.[4] "Within this population, there is group of patients that most clinicians and the public would regard or recognize as frail and at higher risk of adverse outcomes."[5]

On the other hand, the difficulties that created for patients in unplanned situations such as unpredicted hospital admission is anxiety in the daily life that these problems occurs worsen in the elderly compared with others and may lead to side effects to them, such as acquired hospital infections, functional decline, and so on. "Unplanned hospital admissions and readmissions are regarded as markers of costly, suboptimal healthcare, and their avoidance is currently a priority for policymakers in many countries." Early identification of elderly at-risk of functional decline may help to prevent the deleterious effects of hospitalization in near future. Hence, in recent years, the reduction of readmissions has attracted a lot of attention as a way to reduce extra costs and improve treatment outcomes in health organizations.[6]

For example, "in England, Department of Health guidance for the National Health

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Service (NHS) proposes that commissioners should not pay provider hospitals for emergency readmission within 30 days of an index elective (planned) admission. The rate of readmissions will also play an important part in monitoring health system performance, as one of the new English public health "outcome indicators."[7]

"These create even stronger incentives to identify high-risk patients to target care coordination and management strategies that may potentially reduce future inpatient expenditures."[8] Therefore, many countries are looking to beneficial predictive models for identifying people at risk of various diseases or functional decline.[9] Most of unsuccessful old programs are telephone-only interventions that developed update care plans to meet patients' needs, educate patients about self-care and medication adherence, and monitor patients. However, other well-designed office-based interventions have also failed to show major reductions in hospitalizations and spending.[10]

But the advanced risk prediction models can be helpful in identifying at-risk patients and putting this information available to providers to intervene as quickly as possible. Predictive models are often more effective than healthcare professional's judgment or standard checklists (which can identify patients who are at risk either now or in the future).[11]

These models play an important role in heart failure (HF) for risk stratification. However, most of models to date focus on post-discharge outcomes or chronic HF. So to this day, limited models have predicted the risk of stroke for the at-risk group. In stroke, decision-making time for proper treatment and minimizing complications and effects of stroke is crucial and important. Ability to predict patient's stroke prognosis has direct effects on medical decision-making and indirect effects, such as improved follow-up plans, which ultimately can use as a scale for measuring the quality of future health services.[13] Also, identification of patients at high risk of post-stroke pneumonia can be helpful in improve the monitoring and clinical preventive programs.[14] "Hospitalizations, particularly those that require medical intensive care unit (MICU) admission, are difficult for patients and their caregivers can contribute to increasing frailty and mortality risk, and result in substantial costs among those without HIV infection."[15] Modeling is also used to predict the risk factors in infectious and chronic disease, identifying important risk factors, and determining the amount of each factor in disease progression.[16] Even in some cases, predictive models are not only intended to predict patient at risk of admission but also is used to predict postoperative dangers that can used for getting informed consent of patients before surgery, and as a guidance for health policymakers in the postoperative period.[17]

This study was aimed at designing a risk prediction model for identifying the elderly at risk of admission in Iran's hospitals. On the basis of literature review, the present study is the first study reporting predictors of functional decline in elderlies in Iran's hospitals.

It is hoped that by early identifying elderly at risk of hospital admission and taking quick interventions to prevent this kind of hospitalization not only reduces cost burdens on elderly patients and healthcare organizations but also decrease significant side effects of unplanned admission.

Materials and Methods

This is a cross-sectional descriptive study conducted in 2017. In order to formulate and validate a prediction model, the study was done in two development and validation cohort study. For both cohort, patients over 65 years who were admitted to the internal medicine department of three teaching hospitals affiliated to Iran University of Medical Sciences during the first semester of 2017 to participate in the study was selected. The including criteria were the ability to respond to (being in an appropriate mental status) the questions by the patient or patient's companion, informed consent to participate in the study, nontransferring the patient from other ward, especially from the ICUs and hospitalized more than 48 h. Of the 953 eligible patients in the study, 374 did not want to participate in the study, 92 patients were transferred from other wards, 57 patients were in an unacceptable mental status where conveying concepts to them was impossible, and 16 patients died during the study. Finally, 414 patients were selected to participate in the study after obtaining informed consent from them. Simultaneously, a sample include 323 patients with the same characteristics as much as possible was selected for the validation cohort. A two-step approach was used to develop model: (1) identify variables that predict functional decline, (2) modeling and validating that.

Measurement instruments

HARP is an easy operational tool that can identify patients at risk of functional decline during and after admission to the hospital. The HARP tool divides the risk of functional decline into three categories: low risk, moderate, and high risk.[18] In our study, elderly were put in each category based on their risk scores derived from patients' demographic information (age, sex.,), activity of daily living (ADL), nutrition screening tool (NST), and the mini mental state examination (MMSE). These predictors were selected from literature review and suggestion of geriatrics. A two-part questionnaire was used to collect data. The first part of the questionnaire included demographic data, patient medical information (BMI, current illnesses), and clinical patient information (length of stay, discharge status). The second part included the patient's MMSE at the time of admission, ADL, and NST scores, 2 weeks before admission and 3 months after discharge. Within 48 h after admission,

the participants were examined for mental status by the MMSE. In the case of severe cognitive problems (MMSE score less than 16), questions were asked from the patient's companion. Also, 3 months after the admission, the functional status of participants was followed again by phone.

Activity of daily living

The functional status of elderly was assessed by ADL (routine activities people do everyday without assistance). There are six basic ADLs: eating, bathing, getting dressed, toileting, transferring, and the use of incontinence materials. Each item was scored 0 (independent) or 1 (dependent). The total score has a range between zero (complete dependence) and six (complete independence).[19]

Katz ADL index has been translated into Persian and through a survey, its validity and reliability is verified. In this index, functional decline was measured as follows: reduce atleast one score in this index after 3 months of discharge as compared to the score of previous admission status.[20]

Mini mental state examination

MMSE questionnaire is widely used in medical research to measure cognitive status by examining some skills including registration (repeating named prompts), attention and calculation, recall, language, ability to follow simple commands, and orientation.[21] MMSE is a 30-point questionnaire on a scale of 0 (poor) to 30 (excellent), and a score <24 indicated cognitive impairment.[22] In this study, the customized Persian version of the MMSE questionnaire was used for identifying cognitive impairment.[23]

Nutrition screening tool

This questionnaire, which is widely used to examine the nutritional status of elderly people, including four domains as follows: unwanted weight loss over the past 6 months, mid-arm circumference, appetite status, determination of treatment plan. According to the results of this questionnaire, the elderly was classified into three groups:

Proper nutrition status: weight loss <5% over the past 6 months and BMI >18.5

Relative malnutrition: 5--10% weight loss over the past 6 months and BMI <18.5

Malnutrition: weight loss >10% over the 6 past months and BMI <18.5.[24]

Data analyzing

For development and validation cohort, percentage, mean, and standard deviation of variables were calculated. One-variable logistic regression was used to identifying potential predictors associated to functional decline. In the next step, multiple logistic regression was conducted to determine the effect of independent predictors on the dependent variable (functional decline of participants). The criteria that were used for predictors in the multiple logistic regression consist of: one predictor per 10 cases, P value < 0.05, and the opinion of geriatric experts. After analyzing the results of multiple regression, seven independent predictors associated with functional decline were obtained. With these seven predictors, six models were compared and validated in a bootstrap procedure (1,000 bootstrap samples with replacement). Because there was no significant difference between the AUC of each model with a 0.95 confidence interval (range between 0.77 and 0.78) and considering that the target population was the elderly and the preferred model for them is the easiest, it was decided to use the prediction model with four more important predictors. The preferred model was recalibrated by shrinkage of the betas to prevent overfitting by using Hosmer--Lemeshow test. The findings showed that the calibration of the models is adequate with $P > 0.05$ ($P = 0.648$) to determine discriminative value, the c-index was 0.801 (95% CI, 0.749–0.852). Data analysis was performed using SPSS software version 18.

Internal validation of model was measured by resampling techniques (cross-validation and bootstrapping). At first, we generate a bootstrap sample by sampling N individuals with replacement from the original sample. Then, by 100 bootstrap samples, the optimism model was obtained by subtracting the estimated mean of the optimism estimate value from the c-index in the original sample. Finally, for measuring model's discrimination, estimated optimism 0.005, and the optimism-corrected c-index of 0.776 (=0.781 − 0.005) was calculated that showed good discrimination. For external validation, the model examines in independent population of hospitalized patients in a teaching hospital by second data, sensitivity, specificity, positive predictive value, and negative predictive value, were respectively, 0.85%, 0.39%, 0.85%, 0.39%, and AUC = 0.73.

Result

As indicated in Table 1, the average age in the development cohort was 71 years, of which 54% were male and 46% were female. In development cohort, 22% of men and 17% of women experienced functional decline (at least one score in the daily activity index) after 3 months. In the validation cohort, the mean age was 75 years, including 49% of men and 51% women. In 19% of men and 15% of women, functional decline was observed. After analyzing gathered data from demographic characteristics, NST, MMSE, ADL, a total of 41 variables were introduced into one-variable logistic regression. Finally, 15 variables were selected for multiple logistic regression analysis, considered as independent predictors. Seven predictors associated with functional decline were extracted from multiple logistic regression. By these predictors and 1,000 sample bootstrap,

six models were compared. There were no significant differences between models AUC, so, a model with four predictors was chosen. The similar operations were performed in the validation group. The AUC of selected prediction model was 0.71 (95% CI = 0.66 − 76) [Table 2]. Finally, using result of analyzing data, patients were classified into three categories of hospital admission risk prediction: low risk (harp score: 0--1), medium risk (harp score: 2--3), and high risk (harp score: 4--5) [Table 3].

Discussion

Elderly people are hesitant about anticipating age-related issues, tend to trivialize them and to be unwilling to discuss them spontaneously with their physicians. However, it is fine if their doctor brings up the topic with specific questions because that allows initiating a discussion about some of these sensitive problems. It appears that the awareness of the existing geriatric syndromes and functional decline possibilities is rather low. A screening initiative tool like predictive model is therefore an opportunity to address these different issues and to inform patients about existing solutions.[25] So, our aim was to design a model that makes possibility of identifying aging at risk of functional decline and prevent issues that may happen after disabilities.

On the basis of the findings, aging at risk of hospital admission can be identified by answering four questions. These questions are mentioned below:

Is the patient's age more than 85 years?

Is the patient's mini mental status <22?

Does the patient need help for using general transporting?

Is the patient weight loss <5% over the past 6s month and BMI <18.5 [Table 4]?

Because that the target population were seniors, and according to the researchers' experience at the time of collecting data (even the best predictors, if take long-time and need to answer many questions, lead to tiredness and reluctance of the elderly to respond), so the researchers preferred the easiest model to use.

In order to assurance of right selection of variables, the automation process of variables selection was done by

Table 1: Demographic and clinical characteristics of older patients acutely admitted to a general internal ward, baseline and follow-up, development and validation cohort

Demographic and clinical characteristics of elderly people who have been admitted to the internal medicine department	Development cohort number=414	Validation cohort number=323
Age mean	71	70
ages -65-75	37% (153)	32% (104)
ages 75--85	43% (178)	51% (164)
85≥	20%(83)	17%(55)
male Sex % (number)	54%(224)	49%(158)
independently Living % (number)	38%(161)	47%(152)
Living alone % (number)	20%(85)	21%(68)
Mean score of mini mental state test	24	23
(<22=Cognitive impairment) % (number)	28%(116)	36%(117)
Admission reason, (*n*) %		
Infectious diseases	32%(133)	34%(110)
Digestive diseases	16% (67)	23%(74)
Heart disease	11%(46)	10%(32)
Malignancy	7%(31)	7%(22)
other	17%(73)	26%(84)
Functional status 2 weeks before admission, % (*n*)		
Independent,% (number)	72%(298)	76%(245)
Functional status 3 months after admission, % (*n*)		
Independent,% (number)	61% (252)	66%(214)
Difference in functional status preadmission/3 months later, % (*n*)		
(≥1 functional decline (point decline	39%(163)	34%(101)

Table 2: Independ predictors of functional decline

variable	beta	Beta after shrinkage	*P*	OR (95% CI)
patient's age more than 85 years and now lives alone	0.61	0.55	<0.01	1.9 (1.4--2.8)
patient need to help for using general transporting	0.78	0.72	<0.01	2.1 (1.4--3.6)
patient's mini mental status score <22	0.55	0.51	0.02	1.7 (1.2--2.5)
Patient weight loss <5%over the past 6 month and BMI <18.5	0.48	0.42	0.03	1.5 (1--2.2)

Table 3: Risk categories

Hospital Admission Risk Prediction score	
Score=0--1	At low risk of functional decline
Score=2--3	At medium risk of functional decline
Score=4--5	At high risk of functional decline

Table 4: Hospital admission risk prediction

QUESTIONS	YES	NO
Is the patient's age more than 85 years?	1	0
Does the patient's mini mental status <22	1	0
Does the patient need to help for using general transporting?	1	0
Does the Patient weight loss <5%over the past 6 month and BMI <18.5?	2	0
TOTAL SCORE	5	0

bootstrap method. Variables in the bootstrap sample were more frequent (75% of bootstrap samples) inter in the prediction model. To solving problems raised by missing data, the Robbins method was used which analyzed multiple simulated calculations of data sets using standard methods and applying its results to estimating missing values. Also, functional decline status was used to assess the predictive ability of the model, and the difference between the actual and predictive results was measured.

Odds ratios and confidence intervals were calculated. All statistical tests performed in data analyzing were two-way, and $P < .05$ was considered as significant value. The result of the comparison of the two cohorts was as follows:

The participants in the development cohort with higher HARP score were more likely to be older than the validation cohort participants. Most of the participants in development cohort that categorized in high-HARP score group have not been in a good economic situation and live alone. As mentioned above, in the case of low MMSE score, questions were asked from patient's companion. In the opinion of patient's companion, if the their aging members family is not in an appropriate mental health, their family place many restrictions for their activities, especially out-of-home work because of the fear of unplanned events for them. Regarding these issues, it seems to be difficult to comment on whether an inappropriate mental status directly leads to functional decline or restrictions created by relatives' concerns. Nevertheless, elderly people that had family support seem to be more willing to participate in the study. On the basis of literature review, several related studies and their results are almost consistent with the results of the present study. Arnold *et al*. concluded that elderly people with 5% weight loss between consecutive annual visits have a higher risk of incident ADL compared with elderly people with stable weight.[26] Gill *et al*. showed that lower extremity performance score was significantly associated with five subtypes of ADL disability.[27] Rothman *et al*. showed that slow gait speed, low physical activity, and weight loss are significant predictors of chronic incident disability.[28] Ritchie *et al*. claimed that a history of unintentional weight loss at baseline predicts has more rapid decline in ADL.[29] Jacobs *et al*. explained elderly who have less daily out-of-home activity at age 70 years have a higher risk of ADL incident compared with elder who have more out-of-home activity.[30] Al Snih *et al*. showed that elderly people with weight loss of 5% or more within a 2-year follow-up have a higher risk of ADL disability compared with elderly people with stable weight.[31] Stessman *et al*. concluded that elderly people who are not physically active or who do not exercise at least 4 days a week at age 70 years have a higher risk of ADL disability after a 7-year follow-up compared with elderly people who are active physically at age 70 years.[32] Karen *et al*. in their study claim that functional limitations made in everyday planning, everyday memory, and everyday variety domains were associated with the greatest risk of incident functional disability.[33] Lowthian *et al*. showed that pre-existing functional and cognitive impairments are predictor's factors of more decline in patients that followed in time of hospitalization or after discharge.[34] Wojtusiak *et al*. claim that the benchmarks for loss of various ADL functions post-hospitalization could be used in evaluation of interventions designed to prevent functional decline. This kind of prediction provides a platform for understanding post-hospital care among nursing home residents and can be used to understand what diseases, therapies, and care approaches serve as modifiers of these trajectories.[35] On the basis of our findings, geriatrics experts can use the designed model as a predictive tool in order to improve the quality level of healthcare services. The important point of model is easy to use even for non-specialists and need a little time to answer questions.

Ethical considerations

An introduction to the interviews and follow-ups was received from the Ethics Committee of Iran University of Medical Sciences and the interviews were conducted only with those who completed the informed consent form. Also, the data was collected by trained researcher in order to minimize potential errors.

Disclosure statement

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Conflicts of interest

There are no conflicts of interest.

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