Predicting hospitalization in community-living older people: a prognostic study

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Abstract - Predicting hospitalization in older people

Background: For many older people, hospitalization results in functional decline, what leads to a greater dependence in daily life and reduced self-reliance. To prevent loss of function after hospitalization, insight into the predictors of hospitalization in older people is needed.

Aim: To determine predictors of hospitalization in community-living older people (65+).

Methods: This was a secondary data analysis with a prognostic design. Data was obtained by a self-reported questionnaire, supplemented with information from electronic medical record of the general practitioner. The primary outcome of this study was a self-reported hospitalization. Candidate predictors consisted of demographics, medical conditions, daily functioning, general health status and health utilisation. Data were analysed by univariate and multivariate logistic regressions. To evaluate the performance of the model, the discrimination and calibration of the model were determined.

Results: In the total study population (n=1964), 1123 participants (57.2%) were female and the mean age of the participants was 75.9 year. The rate of hospitalizations was 24.7% (n=486). The multivariate analysis showed that a previous hospitalization (Odds Ratio (OR) 2.26; Confidence Interval (CI) 1.77 – 2.87) was the strongest predictor of hospitalization. Other predictors were: male gender, married status, living alone, living with home care, a higher frailty index, poorer physical function, better mental health, poorer vitality, better social functioning, lower quality of life, problems with selfcare, pain and visits to the GP. The final model had a moderate predicting power (Area Under the Curve 0.68; 95% CI 0.65 – 0.71) and an acceptable calibration (p-value 0.697)

Conclusion and recommendations: This study found thirteen predictors of hospitalization in older people. Identification of those predictors gives direction for potential interventions to prevent hospitalization. Particular attention should be paid to individuals with a previous hospitalization. Further research toward reducing avoidable hospitalizations is required.

Keywords: Older people, hospitalization, prediction model, community-living, frailty.

Samenvatting - Ziekenhuisopnames bij ouderen voospellen

Achtergrond: Voor veel ouderen resulteert een ziekenhuisopname in functionele achteruitgang, wat leidt tot een grotere afhankelijkheid in het dagelijks leven en een verminderde zelfredzaamheid. Om functieverlies na ziekenhuisopname te voorkomen, is inzicht nodig in de voorspellers van ziekenhuisopname bij ouderen.

Doel: Voorspellen van ziekenhuisopname bij thuiswonende ouderen (65+).

Methoden: Een secundaire data-analyse met een prognostisch ontwerp werd uitgevoerd. De gegevens zijn verkregen uit een vragenlijst, aangevuld met informatie uit het elektronisch medisch dossier van de huisarts. Het primaire resultaat van deze studie was een zelf-beoordeelde ziekenhuisopname. Kandidaat-voorspellers bestonden uit demografische gegevens, medische aandoeningen, dagelijks functioneren, de algemene gezondheidsstatus en gezondheidsgebruik. Gegevens werden geanalyseerd door een univariate en multivariate logistische regressie. Om de prestaties van het model te evalueren, werden de discriminatie en kalibratie van het model bepaald.

Resultaten: In de totale studiepopulatie (n=1964) waren 1123 participanten (52.7%) vrouw en de gemiddelde leeftijd van de participanten was 75.9 jaar. Het aantal ziekenhuisopnames was 24.7% (n = 486). Uit de multivariate analyse bleek dat een eerdere ziekenhuisopname (Odds Ratio (OR) 2.26; betrouwbaarheidsinterval (BI) 1.77 – 2.87) de sterkste voorspeller van een ziekenhuisopname was. Andere voorspellers waren: mannelijk geslacht, gehuwde status, alleenwonend, thuiswonend met thuiszorg, hogere kwetsbaarheidsindex, slechtere fysieke functie, betere mentale gezondheid, slechtere vitaliteit, beter sociaal functioneren, lagere kwaliteit van leven, problemen met zelfzorg, pijn en bezoeken aan de huisarts. Het uiteindelijke model had een matig voorspellend vermogen (Area Under the Curve 0.68; BI 0.65 - 0.71) en een acceptabele kalibratie (p-waarde 0.697).

Conclusie en aanbevelingen: Deze studie biedt dertien voorspellers van ziekenhuisopname bij ouderen. Identificatie van die voorspellers geeft richting voor mogelijke interventies om ziekenhuisopname te voorkomen. Extra aandacht moet worden besteed aan personen met een eerdere ziekenhuisopname. Verder onderzoek naar het verminderen van vermijdbare ziekenhuisopnames is nodig.

Sleutelwoorden: ouderen, ziekenhuisopname, predictiemodel, thuiswonend, kwetsbaarheid.

Introduction

The global phenomena of ageing populations (> 65 years) and the increasing life expectancy (1) presents healthcare systems with new challenges (2). Due to the aging population, the number of people who are frail and the number of older people with multimorbidity is increasing (2-4). Older people are substantial consumers of healthcare, including hospitalizations (2). In the Netherlands, 33% of the total hospital admissions are people aged 65 years and above, and it is expected that this will increase further in the future (5).

Due to the growing number of older people, there will not be enough room in nursing homes (6,7). It is expected that more older people will live at home in the future, as long as possible. In addition, in the Netherlands there is an increasing trend of older people who prefers to live at home as long as possible (6,7). There is evidence that older people who live at home are more likely to be admitted to hospital than those who live in an institution (8,9).

Hospitalization is a risk for older people because of their increased risk of complications such as infection, malnutrition, delirium, pressure ulcer or side effects of medication (10,11). For many older people, hospitalization results in functional decline despite cure or repair of the condition for which they were admitted (12,13). Approximately 35% of older people are discharged from hospitals with new activity of daily living disabilities, this may increase to 50% in people aged 85 and older (5,14). Boyd et al. found that nearly 70% of those with functional decline had died or had not recovered to baseline function, one year after hospital admission (15). The negative consequences of a hospitalization lead to problems such as greater dependence in daily life and reduced self-reliance. After discharge, this may increase further, which may lead to re-admission, admission to a nursing home or even premature death (15,16).

To prevent loss of function related to hospitalization, it is important to reduce hospitalization in older people. Prevention of hospitalization also leads to an improvement in the quality of life for the older people and a reduction in the use and costs of healthcare (15,16). However, some hospital admissions are unavoidable since they are part of diseases treatment, but others can be avoided, possibly through the use of primary care (17,18). The use of primary care is considered a possible strategy to reduce hospitalization in older people. Previous research shows that home care may prevent hospitalization in older people (18,19). To prevent hospitalization in older people, insight into the predictors of hospitalization is needed. This insight may be very helpful for healthcare professionals in primary care to identify older people who are at risk of hospitalization, and therefore to provide direction for developing interventions to decrease hospitalizations among older people in future.

Previous studies identified multimorbidity, polypharmacy, higher age and male gender as predictors of hospitalization among older people (20). In addition, health problems are not

the only reasons for hospitalization; social influences like living alone and/or low levels of social contacts also influences hospitalization (9). Moreover, previous hospital admissions, have also been reported to be associated with new hospitalizations (21,22). Previous studies included only a few factors (eg, only social factors or drug reactions) (9,23) or focused on specific populations (eg, dementia) (24). However, no study examined a wide range of factors, to predict hospitalization in older people living at home.

Therefore, this study determines the predictors of hospitalization in older people, focusing on a wide range of possible predictors, using self-reported and routine primary care data of the general practitioner.

Aim

The aim of this study was to determine predictors of hospitalization in community-living older people (65 years or older).

Method

Design and source of data

This study was a secondary data analysis and had a prognostic design, with twelve months follow-up. Data from the Utrecht Primary Care PROactive Frailty Trial (U-PROFIT) was used(25). The aim of the U-PROFIT was to determine the effectiveness of a proactive primary care program on the daily functioning of older people in primary care. More information about the trial, is described in the study of Bleijenberg et al (25). For this trial, data has been prospectively collected from 2010 till 2012, with a self-reported questionnaire supplemented with information from electronic medical record (EMR) of the general practitioner (GP). The dataset includes data from in total 3092 older persons, pooled from 39 different GP practices in and around Utrecht, the Netherlands (26).

Population and domain

Recruitment for the U-PROFIT was performed in three primary care networks. Selection of participants was performed by the Utrecht Periodic Risk Identification and Monitoring system (U-PRIM), a software application that is installed in all participating GP practices. U-PRIM has screened for eligible participants, by examining the EMR's in each GP practice(25). In order to be eligible, participants had to be 60 years or older and met at least one of the following criteria: multimorbidity (defined as a frailty index score of ≥ 0.20); polypharmacy (defined as the chronic use of five or more different medications) or care gap in primary care of three or more years (defined as not having consulted the GP in the past three years, except for the yearly influenza vaccination). Individuals who were terminally ill or living in elderly homes or nursing homes were excluded(25).

For the present study, in addition to the eligibility criteria of the U-PROFIT, participants were included when: 1) the participant was 65 years or older; 2) the participant was living in the community; 3) data was administered at baseline and twelve months after baseline.

Procedures

All participants from the U-PROFIT filled in a self-reported questionnaire on baseline (T0), after six months (T6) and after 12 months (T12). In addition, all data regarding polypharmacy, frailty index, care gap, number of emergency department (ED) visits, number of GP consultations and mortality was collected from the EMR of the GP.

Outcome

The primary outcome of this study was a hospitalization, during a twelve months follow-up. Hospitalization was dichotomized measured with the question: 'Have you been hospitalized in the last 12 months?'.

Candidate predictors

Variables from the dataset were selected as candidate predictor based on literature and clinical experience(27,28). This resulted in 32 candidate predictors from the larger set, focused on demographics, medical conditions, daily functioning, general health status, and health utilisation. All candidate predictors were measured on baseline (T0).

Demographics

Demographics in this study (age, gender, country of birth, education, marital status, having children, living situation and social economic status) were obtained self-reported. Education level was categorized into low (primary school or less), medium (secondary school) and high (more than secondary school). The Social Economic Status (SES) was calculated based on the definition of 'social and cultural planning agency' (Dutch: Sociaal en Cultureel Planbureau), and are based on postal areas (29). The scores of the SES were categorized to low, medium and high.

Medical conditions

Information about medical conditions was assessed by the self-reported questionnaire, supplemented with information from the EMR of the GP (frailty index, care gap and medication). To obtain the number of chronic diseases, the participant was asked: ''Have you had any of the following illnesses or ailments during the last 12 months?'', followed by a list of health problems: diabetes, cerebral thrombosis/stroke, heart problems, malignant tumor/cancer, lung problems, urinary incontinence, osteoarthritis / rheumatism of the hips or knees, osteoporosis, hip fracture, other fractures, dizziness with falling, disorders of the

prostate, depression, anxiety/panic disorder, dementia, problems with vision and hearing problems.

The frailty index (FI) was used as an indicator for multimorbidity. The FI uses 50 health deficits based on symptoms, signs, diseases, social problems and functional problems(30). All deficits are routinely encoded in the EMR using International Classification of Primary Care (ICPC) codes. The FI score expresses the number of deficits present as a proportion of the total of 50 deficits. Care gap is defined as the period that patients are out of sight of their GP. This was assessed to include possible care avoiders prone to self-neglect, for example patients with dementia, psychiatric conditions or alcohol abuse . For this study, a care gap was defined as a period of at least three years without GP consultation (excluding the annual influenza vaccination); therefore the variable was dichotomized to 'less than 3 years' and 'more than 3 years' without GP consultation. Two candidate predictors about medication were included in this study; polypharmacy (yes or no) and the total number of medication use. Polypharmacy in this study was defined as five or more different medications in chronic use in the past year (31).

Daily functioning

Daily functioning was assessed with the katz-15. This is an index score of activities of daily living (ADLs) and instrumental activities of daily living (IADLs) (range 0–15); higher scores indicate greater ADL and IADL dependence (32).

General health status

To determine the general health status the measurements RAND-36 and EQ5D were used, complemented with a question about quality of life. The RAND-36 is a health-related quality of life survey (33,34). It is comprised of 36 items, divided into eight subscales with a score range from 0-100; a higher score indicates a better health status (35). For this study, the subscales physical functioning, vitality, mental health and social functioning were included. Beside the four subscales, the item 'perceived health' (dichotomized in excellent/very-good/good and fair/poor) was included(35). The concurrent evaluation of RAND-36 and EQ5D in older people is recommended (34). The EQ-5D questionnaire is a generic instrument to value general health and it defines health according to five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression (34). The five dimensions are measured on a 3-point scale (no problems, some problems, many problems). However, for this study, this was dichotomized in 'no problems' and 'some/many problems'. Quality of life was measured by a number, ranged from 0 - 10 (''what mark would you give your life at the moment?'').

Health utilisation

Information about health utilisation in the last twelve months (hospital admissions, GP visits during evening/night/weekend, home care, temporally admission to nursing home, day care centre and day treatment centre) was measured dichotomized through self-reported questions, such as: 'Did you visit the GP during evenings/nights/weekend, in the last twelve months?'.

Day care centres (Dutch: dagbesteding) and day treatment centres (Dutch: dagbehandeling) are intended for older people who live at home. The purpose of day care is relaxation, and it can contribute to more structure, more guidance and a meaningful daytime activity, for example for people with dementia. Day treatment is a form of group treatment focused on, for example, improving psychological complaints.

Data analysis

Preparing data

Descriptive analyses were used to describe the candidate predictors of the participants on baseline. Continues variables were presented as mean and standard deviation (SD) or as median and interquartile range (IQR) where applicable. Categorical variables were presented as absolute values and percent. Outliers were checked by boxplots, and corrected where necessary. Collinearity was checked by Spearman's correlation. When two candidate predictors were highly correlated (>0.8), one of them was removed; the easiest measurable candidate predictor remained in the study(36).

Data was entered, stored and analysed in IBM SPSS Statistics (SPSS) version 24.

Missing data

Missing data was handled by multiple imputation (MI). In a prediction study, MI is preferred since this results in the best discrimination and validation (34). Missing values were imputed ten times, because a number of five to ten imputations is usually suffice (35). The results of the analyses performed on each of the ten imputed datasets were pooled, to get the final results (37).

Model development

First, univariate associations(odds ratio (OR) and 95% confidence interval (CI)) between candidate predictors and hospitalization were determined with logistic regression. Univariate analyses are desirable to observe differences in a predictor's predictive accuracy from unadjusted (univariate) to adjusted (multivariate) analysis (37).

Next, a multivariate logistic regression was conducted to determine the strongest predictors and to develop a prediction model. Preselection of candidate predictors based on univariate associations for inclusion in the multivariate analyses is not recommended, therefore all candidate predictors were included in the multivariate analysis (37,38).

A backward stepwise selection was used to determine significance predictors in the model. Backward selection starts with a full model comprising all candidate predictors; variables are sequentially removed from the model based on a significance level (37). For the significance level Akaike Information Criterion (AIC), with a p-value of 0.157, was chosen as cut off criteria for the predictors in the backward model. AIC includes a penalty against large models and hence attempts to reduce overfitting(39). After each step, the significant level of each predictor variable was assessed. The final model was created using the enter method, in which significant predictors from the backward stepwise method were included.

Model performance

To evaluate the performance of the model, the discrimination and calibration of the model were determined. Model predictions for binary outcomes need to discriminate between those with and those without the outcome ("Event" versus "No event") (40). To determine the discriminative ability of the model, the area under the receiver operating characteristic (ROC) curve (AUC) was calculated. The ROC curve is a plot of the sensitivity (true positive rate) against 1—specificity (false-positive rate) for consecutive cut-offs for the probability of an outcome (40).

The calibration of the model was examined by the Hosmer-Lemeshow goodness of fit test (40,41). The purpose of an overall goodness-of-fit test is to determine whether the fitted model adequately describes the observed outcome experience in the data (42). The Hosmer-Lemeshow is especially for prediction models, and shows how well the data fits the model. A p-value <0.05 indicates that the model does not fit the data.

Ethical issues

This study was conducted according to the principles of the Declaration of Helsinki (version 9, July 2018). All included participants received a patient information letter from their GP, and signed informed consent to participate in the U-PROFIT. To ensure the privacy of participants, the U-PRIM software encoded personal data through a third-party procedure, making the dataset completely anonymous. The U-PROFIT was approved by the Institutional Review Board of the University Medical Centre Utrecht (UMCU) with protocol ID 10-149/O and registered in the Netherlands Trial Register: NTR2288.

Results

Participants

Out of the 3092 participants in the database, 1964 participants met the inclusion criteria of the present study. The mean age of the participants was 75.9 (SD 7.1) and 1123 participants (57.2%) were female. In total, 486 participants (24.7%) were admitted to the hospital during

the twelve months follow-up. Table 1 describes the baseline characteristics of the total population (n=1964) based on all candidate predictors, and stratified by the presence of hospitalization during the twelve months follow-up.

The overall percentage of missing values was 1.8%. On case-level, 486 (24.7%) cases had missing values on one or more variables. There were no outliers to correct for, and based on the Spearman's rho, there were no high correlations between the variables.

[*Table 1. Baseline characteristics*]

Model development

Univariate analysis

Table 2 shows the univariate associations between each candidate predictor and hospitalization. The strongest significant predictors of hospitalization were: a previous hospitalization in the year before (OR 2.78; 95% CI 2.22 – 3.48), a fair/poor perceived health (OR 2.02; CI 1.62 – 2.54), some/extreme problems with mobility (OR 1.88; CI 1.50 – 2.35), some/extreme problems with selfcare (OR 2.34; CI 1.76 – 3.10) and a higher frailty index (OR 399.24; CI 41.93 – 3801.62).

[*Table 2. Univariate analysis*]

Multivariate analysis

Table 3 shows the results of the multivariate logistic regression model. The strongest significant predictor ($p < 0{,}157$) of hospitalization in the final model was a previous hospitalization in the year before (OR 2.26; 95% CI 1.77 – 2.87). Other predictors of hospitalization in the final model were: male gender, married status, living alone, living with home care, a higher frailty index, poorer physical function, better mental health, poorer vitality, better social functioning, lower quality of life, problems with selfcare, pain and visits to the GP (during evening/night/weekend).

[*Table 3. Multivariate logistic regression model*]

Model performance

The ROC curve yielded a c-statistic of 0.68 (95% CI 0.65 – 0.71), demonstrating moderate predicting power. The Hosmer-Lemeshow goodness of fit test had a p-value of 0.697, which indicates that the model fits the data well.

[*Figure 1. Receiver operating characteristic (ROC) curve*]

Discussion

This study aimed to determine predictors of hospitalization during twelve months follow-up, among community-living older people. In this study, thirteen predictors of hospitalization in

older people were found, focusing on demographics, medical conditions, daily functioning, general health status, and health utilization. The strongest predictor in the model was a previous hospitalization in the year before, which is in line with previous studies (43-45). Therefore, persons with previous hospitalizations are an important target group when planning interventions to prevent hospital admissions. The variables physical function (OR 0.99), mental health (OR 1.01), vitality (OR 0.99) and social activities (OR 1.01) (all items of the RAND-36) were significant predictors in the final model. However, the effect on hospitalization was weak, making the clinical relevance of these results uncertain.

In the present study, age was not a predictor of hospitalization. This is somewhat surprising, since many other studies with a comparable mean age showed an association between age and hospitalization (20,45-48). One likely explanation for this difference, is that the present study included only frail participants, which may eliminate the association with age. It could be that in other studies, age has an association with hospitalization, because age may be capturing other age-related factors (such as frailty) (49,50). Because in the present study all participants were frail due to the inclusion criteria of the study, age may no longer play a role.

A married status was a predictor of hospitalization in the present study. This is quite remarkable, because previous studies found married people have better health outcomes and tend to live longer (51). However, this result is in line with the results of Hallgren at al., who examined factors associated with hospitalization risk among community living middle aged and older persons (48). A possible explanation for this result may be that married persons encourage each other to go to the hospital, which increases hospital admissions among married persons. Somewhat contradictory, in the present study ‘living alone’ is a predictor of hospitalization. Mu et al. demonstrated that the association between hospitalization and living alone vary depends on the cause and length of living alone, which is not determined in the present study (52). In the literature there is no consensus on whether 'living alone' is a predictor or a protective factor of hospitalization (48,52-55), this could be explained by the fact that there are other factors associated with 'living alone', that predict hospitalization.

In the present study living with home care was found as a predictor of hospitalization. This is in line with the study of Dahlberg et al, a prospective study who examined the relationship between social factors and hospital admissions among older people. This can be explained by the fact that persons who receive home care, in generally, have a weaker health condition (56). In addition, primary care, including home care, has an observational role and home care staff may support older people in obtaining health care.

In previous studies, an association was found between the number of chronic diseases and hospitalization (9,44). The number of chronic diseases in the present study, was only significant associated with hospitalization in the univariate analyses. In contrast, in the

multivariate analysis was a higher frailty index a predictor of hospitalization. The association between the frailty index and hospitalization was not examined earlier. However, the frailty index is an indicator for multimorbidity, for which an association with hospitalization is known (45,50). The frailty index used 50 health deficits, and the score expresses the number of deficits present as a proportion of the total 50 deficits (30). The frailty index is more specific than the number of chronic diseases, which is based on a list of seventeen possible chronic diseases. In addition, the frailty-index is collected from the EMR of the GP, while the number of chronic diseases in this study is measured self-reported. This may explain the differences in the multivariate analysis between the number of chronic diseases and frailty index.

The current study analysed a number of predictors, which relations with hospitalization never been examined before. Among these predictors, selfcare, vitality, quality of life and the frailty index were significant predictors of hospitalization.

This study provides insight into the predictors of hospitalization in community-living older persons, which can help healthcare professionals in clinical practice to identify older people at risk for hospitalization. This could help professionals in providing prevention to avoid hospitalization in community living older persons.

Strengths & limitations

To our knowledge, this is the first prediction study on hospitalization in community-living older persons, which examined a wide range of predictors focused on demographics, medical conditions, daily functioning, general health status and health utilization. Other strengths of this study include the availability of a large sample of community-living older people with a large set of variables, and the availability of some medical record data from the GP.

Several limitations should be noted. First, the outcome of this study (hospitalization) was measured with a self-reported questionnaire, which could lead to recall-bias and thus under-reporting of the total hospitalizations in this study. Various studies showed that older people substantially under-report healthcare use, including hospital admissions over a twelve-month period (57-59). Therefore, it is recommended to focus future research on data from electronic medical records. Second, this study did not consider the severity of the reason for hospitalization. It is possible that some predictors from this study predict an unavoidable hospitalization, while others predict an avoidable one. Therefore, no conclusions can be drawn about potentially avoidable hospital admissions. An area for further research concerns the reason for hospital admission, which may be particularly interesting as it can provide insight into avoidable hospital admissions. And with that, even more targeted interventions can be deployed in the future to prevent avoidable hospital admissions. Finally, the present study included only frail participants, thus the generalizability of the findings to all community-living older people may be limited.

Conclusion

In conclusion this study showed that a combination of a wide range of factors related to demographics, medical conditions, daily functioning, general health status, and health utilisation are important to predict hospitalization in community-living older people. Identification of those factors that predict hospitalization gives direction for potential interventions to prevent hospitalization. Particular attention should be paid to individuals with a previous hospitalization in the last year. Further research toward reducing avoidable hospitalizations is required.

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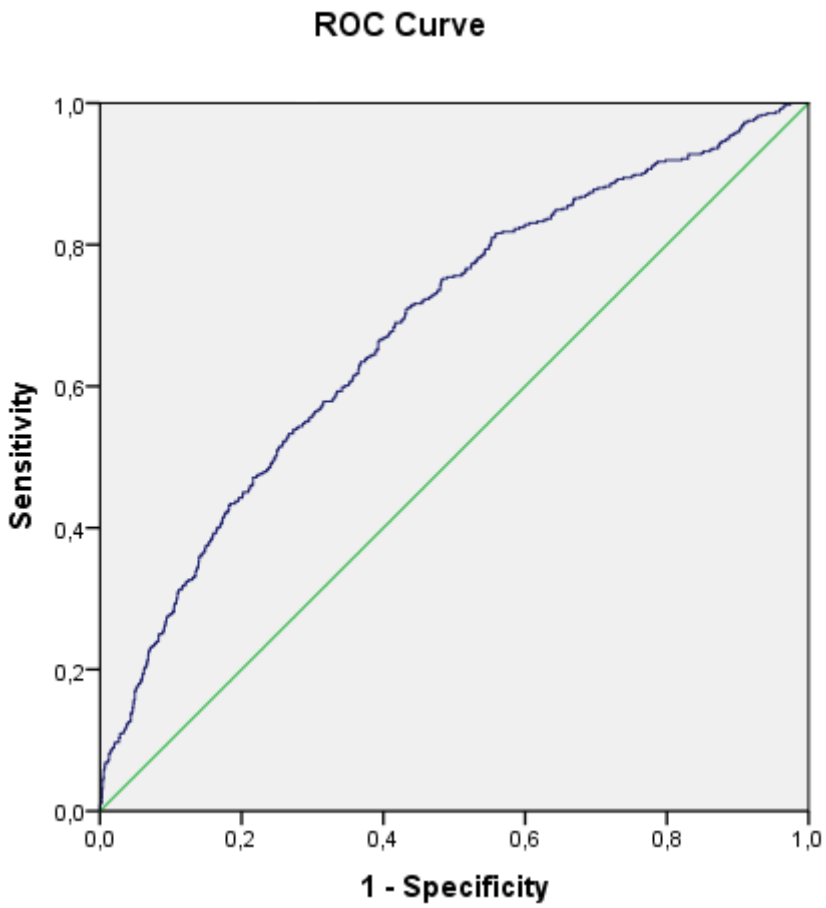

Figure 1. Receiver operating characteristic (ROC) curve, with an area under the ROC curve of 0.68 (95% CI 0.65 – 0.71)

Table 1. Baseline characteristics based on all candidate predictors

	Total Population N= 1964	**Hospitalized N= 484**	**Not hospitalized N= 1480**
Age, mean(SD)	75.9 (7.1)	76.4 (7.2)	75.9 (7.1)
Sex, Female, n (%)	1123 (57.2%)	265 (54.8%)	858 (58%)
Marital status, n (%)			
Married	1049 (53.4%)	258 (53.3%)	791 (53.4%)
Unmarried	900 (45.8%)	221 (45.7%)	679 (45.9%)
Living situation, n (%)			
Independent, with home care	233 (11,9%)	76 (15,7%)	175 (10,6%)
Independent, alone	613 (31,2%)	143 (29,5%)	470 (31,8%)
Independent, with others	1072 (54,6%)	252 (52,1%)	820 (55,4%)
Children, n (%)			
Yes	1701 (86.6%)	417 (86.2%)	1284 (86.8%)
No	261 (13.3%)	66 (13.6%)	195 (13.2%)
Country of birth, Netherlands, n (%)	1836 (93.5%)	456 (94.2%)	1380 (93.2%)
Education, n (%)			
Low education	357 (18.2%)	97 (20%)	260 (17.6%)
Moderate education	1231 (62.7%)	288 (59.5%)	943 (63.7%)
High education	362 (18.4%)	97 (20%)	265 (17.9%)
SES, n (%)			
Low	634 (32.3%)	158 (32.6%)	476 (32.2%)
Moderate	838 (42.7%)	213 (44%)	625 (42.2%)
High	490 (24.9%)	113 (23.3%)	377 (25.5%)
Number of chronic diseases, median(IQR)	2 (1 – 3)	2 (1 – 3)	2 (1 – 3)
Number of medication, median(IQR)	6 (5 – 8)	7 (5 – 9)	6 (5 – 8)
Polypharmacy, n(%)			
Yes	1663 (84.7%)	417 (86.2%)	1246 (84.2%)
No	57 (2.9%)	8 (1.7%)	49 (3.3%)
Frailty index, median(IQR)	0.08 (0.04 – 0.08)	0.08 (0.06 – 0.12)	0.06 (0.04 – 0.1)
Care gap, n (%)			
< 3 years	1641 (83.6%)	413 (85.3%)	1228 (83%)
≥ 3 years	79 (4%)	12 (2.5%)	67 (4.5%)
(i)ADL (katz-15), median(IQR) (Range 0-15)	1 (0 – 2)	1 (0 – 4)	1 (0 – 2)
RAND-36, mean (SD) (Range 0-100)			
Physical functioning	59 (28.8)	50.1 (28.8)	61.9(28.3)
Vitality	57.4 (19.5)	52.9 (19.8)	58.9 (19.2)
Mental health	70.7 (18.1)	68.8 (18.5)	71.4 (17.9)
Social functioning	43.4 (10.5)	43.2 (11.3)	43.5 (10.2)
Perceived health, n (%)			
Excellent/Very good/Good	770 (39.2%)	131 (27.1%)	639 (43.2%)
Fair/Poor	1188 (60.5%)	351 (72.5%)	837 (56.6%)
Quality of life rating, median(IQR)	7 (7 – 8)	7 (6 – 8)	7 (7 – 8)
Mobility (EQ5D), n (%)			
No problems	773 (39.4%)	139 (28.7%)	634 (42.8%)
Some/extreme problems	1179 (60%)	343 (70.9%)	836 (56.5%)
Selfcare (EQ5D), n (%)			
No problems	1715 (87.3%)	386 (79.8%)	1329 (89%)
Some/extreme problems	235 (12%)	96 (19.8%)	139 (9.4%)
Activities (EQ5D), n (%)			
No problems	1037 (52.8%)	206 (42.6%)	831 (56.1%)
Some/extreme problems	924 (47%)	277 (57.2%)	647 (43.8%)
Pain (EQ5D), n (%)			
No pain	596 (30.3%)	99 (20.5%)	497 (33.6%)
Moderate/extreme pain	1349 (68.7%)	378 (78.1%)	971 (65.6%)

Anxiety/depression(EQ5D), n (%)			
Not anxious or depressed	1476 (75.2%)	337 (69.6%)	1139 (77%)
Moderate/extremely anxious or depressed	471 (24%)	141 (29.1%)	330 (22.3%)
Cognitive functions(EQ5D), n (%)			
No problems	1329 (67.7%)	313 (64.7%)	1016 (68.6%)
Some/serious problems	614 (31.3%)	162 (33.5%)	452 (30.5%)
Health utilization in the last 12 months, n (%)			
Hospitalization			
Yes	465 (23.7%)	187 (38.6%)	278 (18.8%)
No	1483 (75.5%)	290 (59.9%)	1193 (80.6%)
GP (evenings, nights, weekends)			
Yes	690 (35.1%)	202 (41.7%)	488 (33%)
No	1221 (62.2%)	270 (55.8%)	951 (64.3%)
Home care			
Yes	526 (26.8%)	162 (33.5%)	364 (24.6%)
No	1414 (72%)	314 (64.9%)	1100 (74.3%)
Temporarily admitted to a home for the aged			
Yes	41 (2.1%)	14 (2.9%)	27 (1.8%)
No	1906 (97%)	467 (96.5%)	1439 (97.2%)
Temporarily admitted to nursing home			
Yes	18 (0.9%)	6 (1.2%)	12 (0.8%)
No	1922 (97.9%)	474 (97.9%)	1448 (97.8%)
Day care centre			
Yes	35 (1.8%)	13 (2.7%)	22 (1.5%)
No	1913 (97.4%)	468 (96.7%)	1445 (97.6%)
Day treatment			
Yes	19 (1%)	8 (1.7%)	11 (0.7%)
No	1922 (97.9%)	471 (97.3%)	1451 (98%)

SD=, Standard Deviation, SES= Social Economic Status, IQR= Interquartile range, (i)ADL= (instrumental) Activities of Daily Living, GP= General practitioner

Table 2. Univariate analysis for the association between each candidate predictor and hospitalization

	OR	CI 95%	P-value
Age	1.01	0.10 – 1.03	0.119
Sex (female)	0.88	0.71 – 1.09	0.214
Marital status (unmarried)	1.00	0.81 – 1.23	0.994
Living situation			
Independent, with others	1 (ref)		
Independent, with home care	1.54	1.14 – 2.08	0.005
Independent, alone	0.97	0.79 – 1.26	0.969
Children (yes)	0.96	0.71 – 1.29	0.781
Country of birth, Netherlands	1.20	0.78 – 1.86	0.412
Education			
Low education	1 (ref)		
Moderate education	0.82	0.63 – 1.07	0.150
High education	0.99	0.71 – 1.37	0.947
SES			
Low	1 (ref)		
Moderate	1.03	0.81 – 1.30	0.832
High	0.90	0.68 – 1.19	0.462
Number of chronic diseases	1.24	1.15 – 1.34	0.000
Number of medications	1.09	1.04 – 1.14	0.000
Polypharmacy (yes)	1.19	0.59 – 239	0.621
Frailty index	399.24	41.93 – 3801.62	0.000
Care gap (≥ 3 years)	0.65	0.28 – 1.48	0.290
(i)ADL (katz-15)	1.16	1.11 – 1.22	0.000
Physical functioning (RAND-36)	0.99	0.98 – 0.99	0.000
Vitality (RAND-36)	0.98	0.98 – 0.99	0.000
Mental health (RAND-36)	0.99	0.99 – 0.10	0.006
Social functioning (RAND-36)	1.00	0.99 – 1.01	0.665
Perceived health			
Excellent/Very good/Good	1 (ref)		
Fair/Poor	2.02	1.62 – 2.54	0.000
Quality of life rating, median(IQR)	0.79	0.72 – 0.86	0.000
Mobility (EQ5D)			
No problems	1 (ref)		
Some/extreme problems	1.88	1.50 – 2.35	0.000
Selfcare (EQ5D)			
No problems	1 (ref)		
Some/extreme problems	2.34	1.76 – 310	0.000
Activities (EQ5D)			
No problems	1 (ref)		
Some /extreme problems	1.73	1.41 – 2.12	0.000
Pain (EQ5D)			
No pain	1 (ref)		
Moderate/extreme pain	1.95	1.53 – 2.50	0.000
Anxiety/depression(EQ5D)			
Not anxious or depressed	1 (ref)		
Moderate/extremely anxious or depressed	1.43	1.14 – 1.80	0.002
Cognitive functions(EQ5D)			
No problems	1 (ref)		
Some/serious problems	1.17	0.94 – 1.46	0.172
Health utilization in the last 12 months (yes)			
Hospitalization	2.78	2.22 – 3.48	0.000
GP (evenings, nights, weekends)	1.47	1.19 – 1.82	0.000

Home care	1.58	1.27 – 1.98	0.000
Temporarily admitted to a home for the aged	1.68	0.88 – 3.20	0.119
Temporarily admitted to nursing home	1.31	0.51 – 3.37	0.575
Day care centre (dagopvang in Dutch)	1.79	0.91 – 3.52	0.091
Day care centre (dagbehandeling in Dutch)	2.20	0.94 – 5.14	0.069

OR= Odds Ratio, CI= Confidence interval, Ref= Reference category, SES= Social Economic Status, (i)ADL= (instrumental) Activities of Daily Living, GP= General practitioner

Table 3. Multivariate logistic regression model for hospitalization

	B	OR (CI 95%)	P value
Constant	-1.406	0.25 (0.09 – 0.65)	0.004
Gender, female	-0.30	0.74 (0.58 – 0.95)	0.016
Marital status, unmarried	-0.32	0.73 (0.48 – 1.11)	0.134
Living situation			
Independent, with others	1 (ref)		
Independent, with home care	0.43	1.54 (0.97 – 2.45)	0.068
Independent, alone	0.41	1.50 (0.96 – 2.35)	0.077
Frailty index	2.70	14.91 (1.21 – 183.64)	0.024
Physical functioning	-0.01	0.99 (0.99 – 1.00)	0.032
Mental health	0.01	1.01 (1.00 – 1.02)	0.030
Vitality	-0.01	0.99 (0.98 – 1.00)	0.114
Social functioning	0.01	1.01 (1.00 – 1.02)	0.042
Quality of life rating	-0.11	0.90 (0.80 – 1.01)	0.063
Selfcare	0.29	1.33 (0.93 – 1.89)	0.114
Pain	0.34	1.41 (1.06 – 1.87)	0.019
Previous hospitalization	0.81	2.26 (1.77 – 2.87)	0.000
GP (evenings, nights, weekends)	0.17	1.18 (0.94 – 1.49)	0.146

B= Beta, OR= Odds Ratio, CI= Confidence interval, Ref= Reference category