Creation of a Rehabilitation Prediction Rule: a Prioritization Procedure

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ABSTRACT

Older adults may require longer recovery periods prior to being discharged from the hospital after an acute care stay. For some, returning to their previous living arrangement may no longer be safe or feasible after an acute care admission, and they may require alternate levels of care. It can be challenging to evaluate which patients may benefit most from inpatient rehabilitation versus those for whom alternate levels of care are more suitable. Using a prioritization procedure, this study identified and ranked predictive factors for successful inpatient rehabilitation (defined as discharge to previous living arrangement) from most to least important. The final round of the prioritization procedure resulted in a list of the top 20 predictive factors, ranked by health-care providers in the field, from most to least important. Predictive factors included demographic information, past medical history factors, acute care illness factors, and results of investigations performed during the index hospitalization. The top ranked predictive factors related to patients' previous living arrangements, level of independence before hospitalization, and presence or absence of cognitive impairment. The bottom ranked predictive factors related to physical measures and results of inpatient investigations at the time of transfer. These findings highlight the importance of considering patients' lived experiences prior to hospitalization when determining who may obtain the greatest benefit from further, intensive inpatient rehabilitation following an acute care hospitalization.

Key words: rehabilitation, hospitals, rehabilitation, clinical decision rules, frail elderly, geriatrics

Introduction

In 2022–2023, there were nearly 2.96 million acute inpatient hospitalizations in Canada, with an age-adjusted average length of hospital stay of 7.3 days.(1) Older adults experience greater comorbidity(2) and frailty(3) that often require longer recovery periods prior to discharge from hospital.(4) Moreover, those with more comorbidities are at higher risk for hospital readmission.(5) For some older adults, returning to their previous living arrangement may no longer be safe or feasible after acute care admission, requiring alternate levels of care.(6) During the time of acute illness, trauma, or perioperative state, it can be challenging to evaluate which patients may benefit most from inpatient rehabilitation versus those for whom alternate levels of care are more appropriate.

Informed by the needs of the end-user, we have taken a pragmatic approach to understanding the factors that impact inpatient rehabilitation outcomes for older adults. This is a first step in an integrated knowledge translation approach to the creation of a prediction tool. Our approach was informed by priority-setting partnership methods, with a focus on ensuring all participants have an equal voice in sharing their lived experience. Prediction models enable clinicians to better advise on lifestyle or therapeutic interventions and incorporate multiple factors (e.g., demographics, medical history, test results) to predict outcomes.(7,8) Predicting outcomes based on single predictors would be insufficient to calculate accurate estimates.(8) While some factors may be associated with successful rehabilitation or the need for alternative living arrangements, it is not clear how they work in combination and predict specific outcomes. With a multivariable prediction model, multiple predictors for a single individual are considered for the diagnosis or prognosis of health outcomes.(8) Once the model is developed, it is validated for use in a clinical setting.(9) This represents a knowledge gap in who may benefit most from further inpatient rehabilitation after acute care admission. Given the increasing older adult population and system-wide pressures, this work is aimed at helping patients understand their options, and to optimize bed flow in a system experiencing significant challenges with overcapacity.

We aim to help patients understand their options, and to optimize bed flow in a system experiencing significant challenges with overcapacity, by identifying factors that predict individual patients' likelihood of successful rehabilitation after an acute care hospital admission (defined as discharge to their previous living arrangement).

METHODS

Study Design

We completed a prioritization exercise to analyze which predictive factors accurately identify patients who will benefit most from inpatient rehabilitation after an acute care admission. We planned to conduct three rounds of surveys. Surveys were hosted online by Qualtrics^{XM} (Seattle, WA; www.qualtrics.com).

Survey Development

We identified and created an initial list of predictive factors separated into four categories based on the clinical experience and expertise of the study team investigators. Chosen predictive factors needed to be accessible and clearly defined.[10]

Prioritization Procedure

Round One participants were asked to review the initial list of predictive factors and suggest additional factors not already included. In Round Two, additional factors provided by Round One participants were reviewed for appropriateness, repetition, feasibility, objectivity, and reliability of data collection by two authors (J.M. and Z.G.). Once the additional factors were reviewed and finalized, they were added to the initial list of predictive factors, resulting in the Round Two survey. Participants were then asked to rank from most (1) to least important (n) in each category. In the final round, the top predictive factors across all categories were identified, and participants were asked to rank them from most (1) to least (20) important.

Recruitment

The study population included health-care providers (e.g., geriatricians, care of the elderly physicians, nursing staff, physical therapists, occupational therapists) in Alberta involved in the clinical care of older adults who receive inpatient rehabilitation. Care providers not providing care to older adults and/or not involved in the pathway from acute care hospitalization through to inpatient rehabilitation were excluded. All participants provided consent prior to completing each survey. This study was approved by the University of Calgary Conjoint Health Research Ethics Board (CHREB23-0745).

Statistical Analysis

Statistical analyses were conducted using Microsoft Excel (version 2402) (Microsoft Corporation, Redmond, WA; www.microsoft.com). We calculated median, interquartile range (IQR), mean, standard deviation, and mode. Medians (IQR) were used to rank participant responses. If two or more predictive factors ranked the same, the predictive factor with the smaller IQR was ranked higher.

RESULTS

Round One

Twenty individuals participated in Round One of the prioritization procedure. Demographic information was not collected. The initial list of predictive factors included four categories: patient demographic factors (n= 9), patient illness factors (n= 18), patient medical history factors (n= 11), and results of investigations performed during the index hospitalization (n= 9) (see Table 1). A total of 19 additional factors were added to the original list based on participants' suggestions, forming the Round Two survey. Additional factors were evaluated for appropriateness, repetition, feasibility, objectivity, and reliability of data collection.

Round Two

Round Two included 15 participants who ranked factors across each section including the factors added after round one. The top predictive factor from the patient demographic category was "Independence with basic activities of daily living (immediately prior to hospitalization)" (Median = 2, IQR = 2.5). The top predictive factor from the patient illness category was "Number of days from admission to the time of initiating physical or occupational therapy" (Median = 5, IQR = 7). The "Presence or absence of a diagnosis of any active malignancy (i.e., not a previously treated cancer or a cancer in remission)" (Median = 3, IQR = 10.75) was rated highest from the patient past medical history category. Finally, "Change in weight from time of index admission to hospital to time of transfer to the acute geriatric unit" (Median = 2.5, IQR = 3) ranked highest in the results of investigations performed during the index hospitalization category. See Table 2 for Round Two rankings.

Round Three and Final Predictive Factors

Finally, Round Three included 13 individuals who ranked the 20 top predictive factors from Round Two from most to least important. Of the 20 predictive factors, four were from the patient demographic category, six from patient illness category, seven from patient past medical history category, and three from results of investigations performed during the index hospitalization category. Two predictive factors not in the top 20 from Round Two were included over higher ranked factors. These two factors are seen in Table 2 (Rank 8 under the patient illness category, and Rank 4 under the results of investigations performed during the index hospitalization category). In these cases, the decision was made to include data that are readily and accurately available in the health electronic records and which had greater face validity.[10] Participants ranked patient demographics highest, prioritizing patients' living arrangements and level of independence immediately prior to the index hospital admission. Participants ranked results of investigations performed during the index hospitalization in the bottom three. The 20 ranked, predictive factors are presented in Table 3.

DISCUSSION

This prioritization exercise identified 20 predictive factors that could help identify patients where inpatient rehabilitation after

TABLE 1.
Round One categorized predictive factors identified by the study team

Patient Demographic Factors
Living alone or with others prior to hospitalization.
Living arrangement prior to hospitalization (i.e., own home/apartment/condominium versus lodge/supportive living).
Area code of residence immediately prior to hospitalization.
Smoking status immediately prior to hospitalization.
Alcohol intake status immediately prior to hospitalization.
Independence with instrumental activities of daily living (immediately prior to hospitalization).
Independent with basic activities of daily living (immediately prior to hospitalization).
Presence or absence of wheelchair use (immediately prior to hospitalization).
Presence or absence of family and other informal caregivers during hospitalization.
Patient Illness Factors
Reason for index hospital admission (e.g., unexpected fall/trauma, stroke, heart attack versus elective surgery).
Number of days from admission to the time of initiating physical or occupational therapy.
Number of days that the patient received physical or occupational therapy on the hospital unit prior to transfer to the acute geriatric unit.
Length of hospital stay prior to transfer to the acute geriatric unit.
Presence or absence of admission to the intensive care unit during their hospital stay.
Presence or absence of need for intermittent haemodialysis during their admission.
Presence or absence of need for parenteral nutrition during their admission.
Presence or absence of physical restraint use at any point during their hospital admission.
Presence or absence of chemical restraint use at any point during their hospital admission.
Presence or absence of delirium at any point during their hospital admission.
Presence or absence of lift use for transfer at any point during their hospital admission.
Presence or absence of polypharmacy (defined as $\geq$10 regular medications at the time of transfer to the acute geriatric unit).
Presence or absence of oxygen use at the time of transfer to the acute geriatric unit.
Presence or absence of enteral nutrition use at the time of transfer to the acute geriatric unit.
Presence or absence of wound(s) at the time of transfer to the acute geriatric unit.
Presence or absence of psychiatry consultation during index hospitalization.
Number of physiotherapy/occupational therapy sessions completed versus declined.
Presence or absence of documentation of behaviors within the electronic health record.
Patient Past Medical History Factors
Presence or absence of a diagnosis of active cancer (i.e. not a previously treated cancer or a cancer in remission).
Presence or absence of severe aortic stenosis.
Presence or absence of end-stage chronic kidney disease.
Presence or absence of end-stage chronic obstructive pulmonary disease.
Presence or absence of end-stage heart failure.
Presence or absence of end-stage chronic liver disease/cirrhosis.
Presence or absence of dementia/cognitive impairment/mild cognitive impairment.
Presence or absence of a neurodegenerative disease other than dementia (e.g., Parkinson's disease).
Presence or absence of visual impairment.
Presence or absence of hearing impairment.
Frailty assessment as documented in the electronic health record.
Results of Investigations Performed During the Hospitalization Factors
Weight at time of transfer to the acute geriatric unit.
Change in weight from time of index admission to hospital and time of transfer to the acute geriatric unit.
Hemoglobin value at the time of transfer to the acute geriatric unit.
Nadir hemoglobin value during the index hospitalization.
Creatinine value at the time of transfer to the acute geriatric unit.
Maximum creatinine value during the index hospitalization
Serum albumin value at the time of transfer to the acute geriatric unit.
Nadir serum albumin value during the index hospitalization.
Blood pressure (mean arterial pressure) at the time of transfer to the acute geriatric unit.

TABLE 2 (part 1 of 2).
Ranked predictive factors from Round One, including those added by participants, using median and interquartile range (IQR) according to factor category

Patient Demographic Factors			
Rank	*Median*	*IQR*	*Predictive Factor*[a]
1	2	2.5	Independence with basic activities of daily living (immediately prior to hospitalization).
2	3	2	Living alone or with others prior to hospitalization.
3	3	3.5	Living arrangement prior to hospitalization (i.e., own home/apartment/condominium versus lodge/supportive living).
4	4	2	Independence with instrumental activities of daily living (immediately prior to hospitalization).
5	4	2.5	Presence or absence of family and other informal caregivers during hospitalization.
6	6	2.5	Presence or absence of wheelchair use (immediately prior to hospitalization).
7	7	2	Alcohol intake status (immediately prior to hospitalization).
8	8	1	Smoking status (immediately prior to hospitalization).
9	9	1	Postal code of residence (immediately prior to hospitalization).
Patient Illness Factors			
Rank	*Median*	*IQR*	*Predictive Factor*
1	5	7	Number of days from admission to the time of initiating physical or occupational therapy.
2	6	6	Presence or absence of delirium at any point during their hospital admission.
3	6	11.5	Number of physiotherapy/occupational therapy sessions completed versus declined.
4	7	5	Length of hospital stay prior to transfer to the acute geriatric unit.
5	7	6.5	Reason for index hospital admission (e.g., unexpected fall/trauma, stroke, heart attack versus elective surgery).
6	7	8.5	Presence or absence of lift use for transfer at any point during their hospital admission.
7	8	8	Presence or absence of physical restraint use at any point during their hospital admission.
8	9	3.5	Presence or absence of admission to the intensive care unit during their hospital stay.
9	9	8.5	Presence or absence of chemical restraint use at any point during their hospital admission.
10	9	9	Number of days that the patient received physical or occupational therapy on the hospital unit prior to transfer to the acute geriatric unit.
11	9	12.5	Presence or absence of documentation of behaviors within the electronic health record.
12	12	6	Presence or absence of need for intermittent hemodialysis during their admission.
13	12	6.5	Presence or absence of need for parenteral nutrition during their admission.
14	12	11	*Current goals of care (GOC) designation.*
15	14	9.5	*Calculated MEWS (Modified Early Warning Score) on the day of transfer to acute geriatric unit (i.e., blood pressure, heart rate, respiratory rate, temperature, alertness).*
16	15	5	Presence or absence of oxygen use at the time of transfer to the acute geriatric unit.
17	15	9	Presence or absence of polypharmacy (defined as ≥10 regular medications at the time of transfer to the acute geriatric unit).
18	16	8.5	*Presence or absence of in-hospital falls.*
19	17	7.5	Presence or absence of wound(s) at the time of transfer to the acute geriatric unit.
20	18	3	Presence or absence of enteral nutrition use at the time of transfer to the acute geriatric unit.
21	20	3	Presence or absence of psychiatry consultation during index hospitalization.

TABLE 2 (part 2 of 2).
Ranked predictive factors from Round One, including those added by participants, using median and interquartile range (IQR) according to factor category

Patient Past Medical History Factors			
Rank	*Median*	*IQR*	*Predictive Factor*
1	3	10.75	*Presence or absence of a diagnosis of any active malignancy (i.e., not a previously treated cancer or a cancer in remission).*
2	3.5	5.75	*Presence or absence of a diagnosis of active hematologic malignancy (i.e., not a previously treated cancer or a cancer in remission).*
3	5	7.25	Presence or absence of dementia/cognitive impairment/mild cognitive impairment.
4	6.5	3.75	Presence or absence of end-stage heart failure.
5	6.5	4.25	Presence or absence of severe aortic stenosis.
6	7.5	2.75	Presence or absence of end-stage chronic obstructive pulmonary disease.
7	7.5	10.75	*Presence or absence of a diagnosis of active solid organ malignancy (i.e., not a previously treated cancer or a cancer in remission).*
8	9	5.25	Presence or absence of end-stage chronic kidney disease.
9	9.5	3	Presence or absence of end-stage chronic liver disease/cirrhosis.
10	10	6.5	Presence or absence of a neurodegenerative disease other than dementia (e.g., Parkinson's disease).
11	12	16.75	*Number of admissions to the hospital in the year prior to acute geriatric unit transfer.*
12	13	7.5	Frailty assessment as documented in the electronic health record.
13	13	9.25	*Presence or absence of substance use disorder.*
14	14.5	14	*Number of emergency department visits in the year prior to acute geriatric unit transfer.*
15	15	9.5	Presence or absence of visual impairment.
16	15.5	8.25	Prescence or absence of hearing impairment.
17	16	10.25	*Presence or absence of chronic pain.*
18	16.5	3.75	*Presence or absence of a mood disorder (e.g., depression or anxiety).*
19	19	4.5	*Presence or absence of spinal stenosis.*
20	19.5	4	*Presence or absence of diabetes mellitus.*
21	19.5	8.5	*Presence or absence of documented falls history.*
22	20	3.75	*Presence or absence of osteoporosis.*
23	20	4.75	*Presence or absence of recent hip replacement.*
24	20	6.5	*Presence or absence of recent fracture.*
Results of Investigations Performed During the Index Hospitalization Factors			
Rank	*Median*	*IQR*	*Predictive Factor*
1	2.5	3	Change in weight from time of index admission to hospital and time of transfer to the acute geriatric unit.
2	3	3	Blood pressure (mean arterial pressure) at the time of transfer to the acute geriatric unit.
3	3	3.75	Weight at time of transfer to the acute geriatric unit.
4	4	3.75	Hemoglobin value at the time of transfer to the acute geriatric unit.
5	6	2.75	Creatinine value at the time of transfer to the acute geriatric unit.
6	6	3.75	Nadir hemoglobin value during the index hospitalization.
7	6.5	4	Serum albumin value at the time of transfer to the acute geriatric unit.
8	7	1.75	Maximum creatinine value during the index hospitalization.
9	8.5	3.5	Nadir serum albumin value during the index hospitalization.
10	10	4.25	*Sodium value at the time of transfer.*
11	11	2	*Nadir sodium value during the index hospitalization.*
12	12	2	*Thyroid stimulating hormone value.*

[a]Italicized factors are those added or edited from review of participant suggestions given in Round One.

acute illness may be most beneficial. This work will help to inform further work on prediction modelling.

Prior function and living arrangements are key when predicting rehabilitation outcomes. The consensus of this prioritization procedure indicated that patient independence with activities of daily living and their living arrangements prior to admission were important predictive factors. These key factors are directly related to patients' available resources after acute care and their baseline function vs. need for support, thus making key factors in recovery.

As older Canadians experience higher degrees of frailty and comorbidity, there are more acute care admissions and thus inpatient rehabilitation.[11] Recent Canadian research validated a mortality risk model for older adults in the home care setting and found, similar to our study, that measures of function (i.e., basic and instrumental activities of daily living) were the most important in predicting deterioration and death.[12] Additionally, older adults who live with others may be more likely to have family and friends who are able to provide support, whereas those who live in a supportive

TABLE 3.
Top 20 ranked predictive factors from round two using median and interquartile range (IQR)

Rank	*Median*	*IQR*	*Predictive Factor*	*Factor Category*
1	3	5	Independence with basic activities of daily living (immediately prior to hospitalization).	Patient demographic
2	4	5	Living alone or with other(s) prior to hospitalization.	Patient demographic
3	5	8	Independence with instrumental activities of daily living (immediately prior to hospitalization).	Patient demographic
4	6	6	Presence or absence of dementia/cognitive impairment/mild cognitive impairment.	Patient past medical history
5	6	9	Number of days from admission to the time of initiating physical or occupational therapy.	Patient illness
6	7	6	Living arrangement prior to hospitalization (i.e., own home/apartment/ condominium versus lodge/supportive living).	Patient demographic
7	8	7	Reason for index hospital admission (e.g., unexpected fall/trauma, stroke, heart attack versus elective surgery).	Patient illness
8	9	6	Presence or absence of delirium at any point during their hospital admission.	Patient illness
9	10	7	Presence or absence of severe aortic stenosis.	Patient past medical history
10	10	9	Length of stay prior to transfer to the acute geriatric unit.	Patient illness
11	11	7	Presence or absence of end-stage chronic obstructive pulmonary disease.	Patient past medical history
12	11	8	Presence of absence of lift use for transfer at any point during their hospital admission.	Patient illness
13	12	6	Presence or absence of admission to the intensive care unit during their hospital stay.	Patient illness
14	12	7	Presence or absence of end-stage heart failure.	Patient past medical history
15	12	10	Presence or absence of a diagnosis of any active malignancy (i.e., not a previously treated cancer or cancer in remission).	Patient past medical history
16	13	10	Presence or absence of a diagnosis of active solid organ malignancy (i.e., not a previously treated cancer or a cancer in remission).	Patient past medical history
17	14	9	Presence or absence of a diagnosis of active hematologic malignancy (i.e., not a previously treated cancer or a cancer in remission).	Patient past medical history
18	18	0	Change in weight from time of index admission to hospital and time of transfer to the acute geriatric unit.	Results of investigations performed during index hospitalization
19	19	0	Hemoglobin value at the time of transfer to the acute geriatric unit.	Results of investigations performed during index hospitalization
20	20	1	Blood pressure (mean arterial pressure) at the time of transfer to the acute geriatric unit.	Results of investigations performed during index hospitalization

living environment prior to admission may be more frail and need additional support.[5]

Severity of illness while in acute care will impact rehabilitation. Requiring intensive care unit admission or experiencing delirium were also key factors when predicting rehab outcomes. Both represent more complicated and/or prolonged hospital stay and are associated with worsening function. This is especially the case given that we know delirium and intensive care unit stays during hospitalization are independently associated with increased risk of death, institutionalization, and incident dementia.[13]

Baseline comorbidities that limit function and exercise capacity will affect rehabilitation trajectories. Certain comorbidities, such as severe chronic obstructive pulmonary disease, end-stage heart failure, and any cancer were associated with a high risk of mortality, and poor baseline function and recovery post-acute exacerbation were also key factors.[14–16] For example, the hazard ratio for mortality increases with each increment in the Global Initiative for Chronic Obstructive Lung Disease (GOLD) classifications.[17] Similarly, in patients with severe asymptomatic aortic stenosis, the risk of death is 5% at one year[18] and rises to 50% for those with severe symptomatic aortic stenosis.[19] Presence of comorbidities can greatly impact patient outcomes in a clinical setting.

Limitations

This study recruited participants from a single, urban setting. Additionally, we did not include patients or referring providers. These two considerations limit the generalizability of our results. Future research could expand on these results by collecting data across a broader provincial or national region and including patients and other providers in their recruitment strategies.

CONCLUSION

The factors ranked demonstrate a consensus of health-care providers' experiences working in geriatric medicine and acute rehabilitation regarding which factors are most predictive of acute care rehabilitation outcomes. These results are the first step toward more evidence-based decision-making to provide equitable access to a scarce resource.

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CONFLICT OF INTEREST DISCLOSURES

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