

Functional improvement after inpatient rehabilitation in community hospitals following acute hospital care

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ABSTRACT

Introduction: There are limited studies exploring functional improvement in relation to characteristics of patients who, following acute hospital care, receive inpatient rehabilitation in community hospitals. We evaluated the association of acute hospital admission-related factors with functional improvement on community hospital discharge.

Methods: We conducted a retrospective cohort study among patients who were transferred to community hospitals within 14-day post-discharge from acute hospital between 2016 and 2018. Modified Barthel Index (MBI) on a 100-point ordinal scale was used to assess functional status on admission to and discharge from the community hospital. We categorised MBI into 6 bands: 0–24, 25–49, 50–74, 75–90, 91–99 and 100. Multivariable logistic regression models were constructed to determine factors associated with categorical improvement in functional status, defined as an increase in at least one MBI band between admission and discharge.

Results: A total of 5,641 patients (median age 77 years, interquartile range 69–84; 44.2% men) were included for analysis. After adjusting for potential confounders, factors associated with functional improvement were younger age, a higher MBI on admission, and musculoskeletal diagnosis for the acute hospital admission episode. In contrast, a history of dementia or stroke; lower estimated glomerular filtration rate; abnormal serum albumin or anaemia measured during the acute hospital episode; and diagnoses of stroke, cardiac disease, malignancy, falls or pneumonia; and other chronic respiratory diseases were associated with lower odds of functional improvement.

Conclusion: Clinicians may want to take into account the presence of these high-risk factors in their patients when planning rehabilitation programmes, in order to maximise the likelihood of functional improvement.

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Keywords: Barthel Index, community hospitals, functional status, inpatients, rehabilitation, risk factors

INTRODUCTION

Early inpatient rehabilitation therapy has been known to have beneficial impact on physical function and mobility, psychological status and cognitive function of patients following an acute medical event requiring hospitalisation.¹ Following an acute hospital care, those who have been identified to have potential for functional improvements are often transferred to a community

hospital or rehabilitation unit for physical therapy and rehabilitation. Patients typically go through a series of multidisciplinary therapeutic interventions. These interventions aim to restore their functional capability, activities of daily living (ADL) and cognitive function,^{2,3} with the overall objective of improving quality of life and reducing complications arising from their disability. Appropriate level of medical stability, significant level

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CLINICAL IMPACT

What is New

- Our study identified the determinants of functional improvement in patients who were transferred from an acute hospital to community hospital for inpatient rehabilitation.
- Patient factors such as age, comorbidities, psychotropic medication use, laboratory parameters, and the principal reason for admission to acute hospital were associated with functional improvement during extended care at the community hospital.

Clinical Implications

- Factors associated with the high and low odds of functional improvement may support healthcare professionals in the planning of personalised rehabilitation programmes with the aim of achieving the best possible functional improvement in patients.

of functional disability and capability to learn in patients are important criteria for the development of a rehabilitation plan.⁴

In Singapore, inpatient rehabilitation service is offered in acute care hospitals and community hospitals. There are currently 9 community hospitals in operation providing medical, nursing and rehabilitation care.⁵ The majority of patients in the community hospitals are transferred from an acute hospital after treatment and stabilisation of their condition. The additional stay in the community hospital is intended to reduce post-illness disability and functional impairment, so as to optimise their ability to perform ADL and function within the home environment. Rehabilitative care including physical, occupational and speech therapies are conducted by trained professionals, and individualised to the specific needs of each patient.

Literature on the benefits of inpatient rehabilitation in relation to functional status after an acute event has typically looked at outcomes in persons with a certain disease condition such as stroke or spinal injuries.^{4,6-8} However, many patients receiving care in community hospitals have multiple comorbidities or are extremely frail. In some cases, their decline in functional impairment may possibly be due to deconditioning rather than a direct consequence of the event that caused their admission. Furthermore, this topic has not been well-explored in Asian countries. We were thus motivated to evaluate rehabilitation outcomes in a group of patients who

were discharged from an acute hospital for inpatient rehabilitation therapy in community hospitals. This article describes the factors from acute hospital admission that are associated with functional improvement at the point of discharge from community hospital.

METHODS

Study design, setting and population

We conducted a retrospective closed cohort study among patients hospitalised in Tan Tock Seng Hospital (TTSH) in Singapore, a 1,700-bed acute care tertiary hospital. The patients were discharged to one of 2 affiliated community hospitals: a 370-bed community hospital A, or 472-bed community hospital B. Study participants were selected based on the following eligibility criteria:

- (1) patients discharged from TTSH between January 2016 and December 2018; and
- (2) patients transferred subsequently to either community hospital A or B within 14 days of discharge from TTSH.

Outcome measurement

The Modified Barthel Index (MBI),^{9,10} a 100-point ordinal scale for the assessment of a patient's functional state, was determined within 48 hours of admission and at discharge. MBI assesses 5 subcategories for each of the 10 ADL comprising personal hygiene, feeding, bathing, toileting, stair climbing, dressing, bladder control, bowel control, ambulation and transfers. In the absence of established MBI cut-off scores, we selected the MBI bands used by the Ministry of Health Singapore.¹¹ Patients were categorised into 6 bands: total dependency (score of 0–24), severe dependency (25–49), moderate dependency (50–74), mild dependency (75–90), minimal dependency (91–99) and independent (100).¹¹ Taking the first recorded MBI score at admission and the last MBI score on discharge, improvement in MBI was defined as an increase in a minimum of 1 MBI band on discharge from the community hospital. We excluded 14 patients who had an MBI of 100 on admission to the community hospital.

Explanatory variables

Data recorded during the acute hospital care episode that could potentially be associated with functional improvement were extracted for the study. All data were electronically extracted from the electronic medical records of the hospital in a standardised fashion. We included the following variables: age (<65, 65–74, 75–84, ≥85 years), sex, ethnicity, type of residential accommodation (rental flat versus non-rental flat)

as a surrogate index for social status, prescribed psychotropic medications (i.e. psychotherapeutics, anxiolytics/sedatives/hypnotics, anticonvulsants and/or antiparkinsonian medication),¹² Hospital Frailty Risk Score (low risk <5, intermediate risk 5–15, and high risk >15)¹³ and Charlson's Comorbidity Index (CCI).¹⁴ Additionally, the last available values of the laboratory parameters during the acute hospital stay were also extracted; the following laboratory variables were included: serum albumin (normal ≥ 35 g/L, mild hypoalbuminaemia 25–34g/L, marked hypoalbuminaemia <25g/L),¹⁵ blood urea (low <2.5mmol/L in men and <2.0mmol/L in women, normal 2.5–7.5mmol/L in men and 2.0–6.5mmol/L in women, and high >7.5mmol/L in men and >6.5mmol/L in women), anaemia assessed by haemoglobin (normal ≥ 13 g/dL in men and ≥ 12 g/dL in women, mild anaemia 10.0–12.9g/dL in men and 10.0–11.9g/dL in women, and moderate to severe anaemia <10.0g/dL in men and women),¹⁶ serum sodium (hypernatraemia ≥ 145 mmol/L, normal 135–144mmol/L, mild hyponatraemia 130–134mmol/L, and moderate to severe hyponatraemia <130mmol/L), estimated glomerular filtration rates (eGFRs) calculated from serum creatinine using Chronic Kidney Disease Epidemiology Collaboration equation and categorised by levels of eGFR (≥ 60 , 30–59, and <30mL/min/1.73m²),¹⁷ red blood cell (RBC) count, platelets, white blood cell (WBC) count, as well as neutrophil, and lymphocyte counts (<1.5 and $\geq 1.5 \times 10^9$ /L) as a marker of nutritional status.^{18–20} Based on electronically extracted principal discharge diagnosis during acute hospital care, we further categorised the patients into 8 distinct groups: (1) injuries/fractures, (2) stroke, (3) musculoskeletal (e.g. spondylopathies and arthrosis/arthritis such as knee arthrosis, gouty arthritis, rheumatoid arthritis and dorsalgia), (4) cardiac conditions, (5) malignancy/palliative conditions, (6) falls (without fractures), (7) acute exacerbation of chronic obstructive pulmonary disease (AE-COPD)/pneumonia/lower respiratory tract infections (LRTIs), and (8) other infections; and the remaining patients as others.

Statistical analysis

Characteristics of patients were described with frequencies and percentages, or median values and interquartile ranges (IQRs) as appropriate. The differences in characteristics were compared using chi-square test or Mann-Whitney U test. Multivariable logistic regression analysis was performed to assess the determinants associated with functional outcome improvement. Explanatory variables that were

significantly different between the groups that improved MBI bands and that did not, and variables that were judged as clinically important by clinicians (age, sex, race, MBI on admission, frailty and comorbidities) were selected to be included in the multivariable models. We assessed variables for correlation, and excluded highly correlated variables (RBC count and blood urea were excluded due to correlation with haemoglobin and eGFR, respectively). Four nested multivariable regression models were developed, with improvement in MBI band as an outcome variable and the following variables as predictors: demographics, MBI score on admission and principal discharge condition in model 1, addition of the Hospital Frailty Risk Score category and pre-existing comorbidities in model 2, addition of overall psychotropic medication use and number of medication prescribed on discharge in model 3, and final addition of laboratory test results in model 4. As supplementary analysis, we further performed a logistic regression stratified by principal discharge condition (including injuries/fractures, stroke, musculoskeletal disorders, AE-COPD/pneumonia/LRTIs, other infections and others considering the number of participants in each category) using explanatory variables from model 4. All reported *P* values were two-tailed, with an α level of 0.05. All statistical analyses were conducted using R version 4.0.2 (RStudio Team, Vienna, Austria).

The study was approved with waiver of informed consent by Domain Specific Review Board of the National Healthcare Group, Singapore (reference ID: 2021/00404).

RESULTS

Characteristics of study population

From 2016 to 2018, a total of 5,641 patients aged 23–111 years (median age 77, IQR 69–84) were included for analysis (Fig. 1). Fig. 2 illustrates the distribution of absolute MBI score on admission to and discharge from community hospital stratified by disease condition. Improvement in MBI score at discharge was seen most among patients who underwent rehabilitation for musculoskeletal disorders and injuries/fractures. The demographic and clinical characteristics of the study population are shown in Table 1. Nearly half ($n=2,831$, 50.2%) had improvement in their MBI band. Those who improved tended to be younger (median age 76 years, IQR 68–83 vs 79 years, IQR 71–86; $P<0.001$), women (58.6% vs 53.1%; $P<0.001$), had a higher MBI score on admission (median 58, IQR 43.5–67 vs 50, IQR 26–61; $P<0.001$), a longer length of stay in the

Table 1. Characteristics of patients and risk factors of improvement in MBI band

Characteristics	Total (N=5641)	Improvement by at least 1 MBI band		P
		No (n=2810)	Yes (n=2831)	
Demographics				
Age, median (IQR), years	77 (69.0–84.0)	79 (71.0–86.0)	76 (68.0–83.0)	<0.001
Age category, no. (%)				<0.001
<65 years	784 (13.9)	341 (12.1)	443 (15.6)	
65–74 years	1461 (25.9)	643 (22.9)	818 (28.9)	
75–84 years	2019 (35.8)	1004 (35.7)	1015 (35.9)	
≥85 years	1377 (24.4)	822 (29.3)	555 (19.6)	
Sex, no. (%)				<0.001
Male	2492 (44.2)	1319 (46.9)	1173 (41.4)	
Female	3149 (55.8)	1491 (53.1)	1658 (58.6)	
Ethnicity, no. (%)				0.059
Chinese	4812 (85.3)	2364 (84.1)	2448 (86.5)	
Malay	305 (5.4)	157 (5.6)	148 (5.2)	
Indian	324 (5.7)	176 (6.3)	148 (5.2)	
Others	200 (3.5)	113 (4.0)	87 (3.1)	
Reside in rental flat, no. (%)	596 (10.6)	271 (9.6)	325 (11.5)	0.025
Details of hospital admission				
MBI score on admission, median (IQR)	53 (35–65)	50 (26–61)	58 (43.5–67)	<0.001
MBI score on admission category, no. (%)				<0.001
0–24	927 (16.4)	653 (23.2)	274 (9.7)	
25–49	1524 (27.0)	721 (25.7)	803 (28.4)	
50–74	2603 (46.1)	1162 (41.4)	1441 (50.9)	
75–90	532 (9.4)	240 (8.5)	292 (10.3)	
91–99	55 (1.0)	34 (1.2)	21 (0.7)	
Diagnosis at discharge from acute care hospital				<0.001
Injuries and fractures	1944 (34.5)	834 (29.7)	1110 (39.2)	
Stroke	717 (12.7)	430 (15.3)	287 (10.1)	
Musculoskeletal conditions	567 (10.1)	130 (4.6)	437 (15.4)	
Cardiac conditions	178 (3.2)	111 (4.0)	67 (2.4)	
Malignancy and palliative conditions	155 (2.7)	87 (3.1)	68 (2.4)	
Falls	161 (2.9)	95 (3.4)	66 (2.3)	
AE-COPD, pneumonia and other LRTIs	522 (9.3)	287 (10.2)	235 (8.3)	
Other infections	857 (15.2)	509 (18.1)	348 (12.3)	
Others	540 (9.6)	327 (11.6)	213 (7.5)	
Community hospital length of stay, median (IQR), days	29 (18–43)	25 (14–40)	32 (23–46)	<0.001

Table 1. Characteristics of patients and risk factors of improvement in MBI band (Cont'd)

Characteristics	Total (N=5641)	Improvement by at least 1 MBI band		P
		No (n=2810)	Yes (n=2831)	
Comorbidities				
Frailty Risk Score, median (IQR)	9.4 (4.7–15.5)	10.8 (6.0–17.4)	8.1 (3.7–13.8)	<0.001
Frailty Risk Score category, no. (%)				<0.001
Low risk (<5)	1484 (26.3)	576 (20.5)	908 (32.1)	
Intermediate risk (5–15)	2666 (47.3)	1332 (47.4)	1334 (47.1)	
High risk (>15)	1491 (26.4)	902 (32.1)	589 (20.8)	
CCI, median (IQR)	3 (1.0–5.0)	3 (2.0–5.0)	2 (0.0–4.0)	<0.001
CCI category, no. (%)				<0.001
Fair (≤5)	4557 (80.8)	2110 (75.1)	2447 (86.4)	
Poor (>5)	1084 (19.2)	700 (24.9)	384 (13.6)	
Patients with the following comorbidity, no. (%)				
Dementia	910 (16.1)	628 (22.3)	282 (10.0)	<0.001
Chronic pulmonary disease	680 (12.1)	341 (12.1)	339 (12.0)	0.853
Chronic liver disease	349 (6.2)	203 (7.2)	146 (5.2)	0.001
Diabetes mellitus	2546 (45.1)	1381 (49.1)	1165 (41.2)	<0.001
Renal disease	1482 (26.3)	903 (32.1)	579 (20.5)	<0.001
Tumour	561 (9.9)	304 (10.8)	257 (9.1)	0.029
Stroke	1862 (33.0)	1108 (39.4)	754 (26.6)	<0.001
Congestive heart failure/myocardial infarct	1219 (21.6)	737 (26.2)	482 (17.0)	<0.001
Medications prescribed, no. (%)				
Overall psychotropic medications use ^a	2693 (47.7)	1462 (52.0)	1231 (43.5)	<0.001
Use of following medications				
Psychotherapeutics	1339 (23.7)	781 (27.8)	558 (19.7)	<0.001
Anxiolytics/sedatives/hypnotics	715 (12.7)	394 (14.0)	321 (11.3)	0.002
Anticonvulsants	1631 (28.9)	877 (31.2)	754 (26.6)	<0.001
Antiparkinsonians	58 (1.0)	29 (1.0)	29 (1.0)	0.977
Medications on discharge, no. (%)				
<9	1326 (23.5)	614 (21.9)	712 (25.2)	
9–11	1617 (28.7)	834 (29.7)	783 (27.7)	
12–14	1466 (26.0)	720 (25.6)	746 (26.4)	
>14	1232 (21.8)	642 (22.8)	590 (20.8)	
Laboratory parameters, no. (%)				
eGFR				<0.001
≥60mL/min/1.73m ²	3968 (70.3)	1829 (65.1)	2139 (75.6)	
30–59mL/min/1.73m ²	1180 (20.9)	644 (22.9)	536 (18.9)	

Table 1. Characteristics of patients and risk factors of improvement in MBI band (Cont'd)

Characteristics	Total (N=5641)	Improvement by at least 1 MBI band		<i>P</i>
		No (n=2810)	Yes (n=2831)	
<30mL/min/1.73m ²	451 (8.0)	319 (11.4)	132 (4.7)	
Unknown	42 (0.7)	18 (0.6)	24 (0.8)	
Albumin				<0.001
Normal	1143 (20.3)	504 (17.9)	639 (22.6)	
Mild hypoalbuminaemia	2451 (43.4)	1318 (46.9)	1133 (40.0)	
Marked hypoalbuminaemia	651 (11.5)	427 (15.2)	224 (7.9)	
Unknown	1396 (24.7)	561 (20.0)	835 (29.5)	
Urea				<0.001
Low	179 (3.2)	98 (3.5)	81 (2.9)	
Normal	3766 (66.8)	1728 (61.5)	2038 (72.0)	
High	1582 (28.0)	943 (33.6)	639 (22.6)	
Unknown	114 (2.0)	41 (1.5)	73 (2.6)	
Haemoglobin				<0.001
Normal	1262 (22.4)	586 (20.9)	676 (23.9)	
Mild anaemia	2860 (50.7)	1363 (48.5)	1497 (52.9)	
Moderate to severe anaemia	1490 (26.4)	847 (30.1)	643 (22.7)	
Unknown	29 (0.5)	14 (0.5)	15 (0.5)	
Sodium				<0.001
Normal	3772 (66.9)	1857 (66.1)	1915 (67.6)	
Mild hyponatraemia	1219 (21.6)	619 (22.0)	600 (21.2)	
Moderate to severe hyponatraemia	150 (2.7)	93 (3.3)	57 (2.0)	
Hypernatraemia	43 (0.8)	31 (1.1)	12 (0.4)	
Unknown	457 (8.1)	210 (7.5)	247 (8.7)	
RBC (10 ¹² /L), ^b median (IQR)	3.7 (3.3–4.2)	3.7 (3.3–4.1)	3.8 (3.4–4.2)	<0.001
WBC (10 ⁹ /L), ^c median (IQR)	8.2 (6.6–9.9)	8.2 (6.6–10.0)	8.2 (6.6–9.9)	0.699
Lymphocytes (10 ⁹ /L), ^c median (IQR)	1.4 (1.0–1.8)	1.4 (1.0–1.8)	1.4 (1.1–1.9)	0.012
Lymphocytes (10 ⁹ /L) category, no. (%)				0.101
<1.5	2990 (53.0)	1529 (54.4)	1461 (51.6)	
≥1.5	2620 (46.4)	1265 (45.0)	1355 (47.9)	
Unknown	31 (0.5)	16 (0.6)	15 (0.5)	
Neutrophils (10 ⁹ /L), ^c median (IQR)	5.7 (4.3–7.3)	5.7 (4.3–7.4)	5.6 (4.3–7.3)	0.676
Neutrophil-to-lymphocyte ratio, ^c median (IQR)	4.0 (2.7–6.0)	4.0 (2.8–6.1)	4.0 (2.7–5.8)	0.101
Platelets (10 ⁹ /L), ^c median (IQR)	287.0 (221.0–375.0)	285.0 (218.0–373.0)	289.0 (223.0–377.0)	0.127

AE-COPD: acute exacerbation of chronic obstructive pulmonary disease; CCI: Charlson's Comorbidity Index; eGFR: estimated glomerular filtration rate; IQR: interquartile range; LRTIs: lower respiratory tract infections; MBI: Modified Barthel Index; RBC: red blood cells; WBC: white blood cells

^aIncludes the use of psychotherapeutics, anxiolytics/sedatives/hypnotics, anticonvulsants, and/or antiparkinsonians

^bn (%) missing = 34 (0.6)

^cn (%) missing = 31 (0.5)

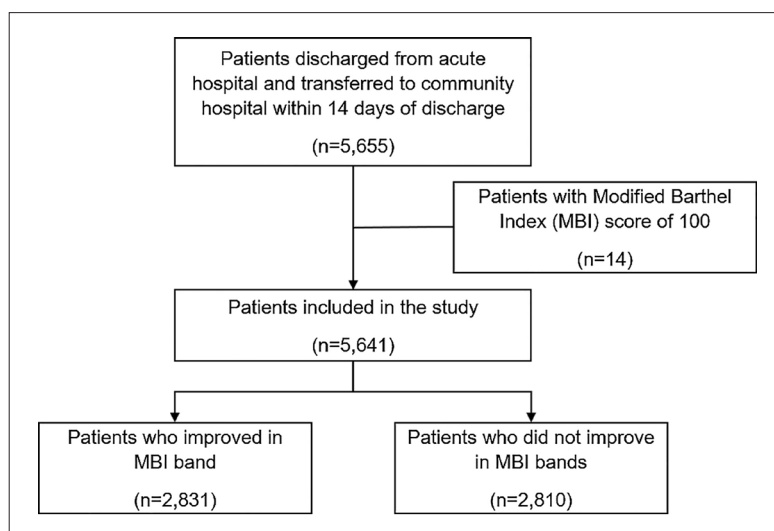


Fig. 1. Participants flow diagram for the study.

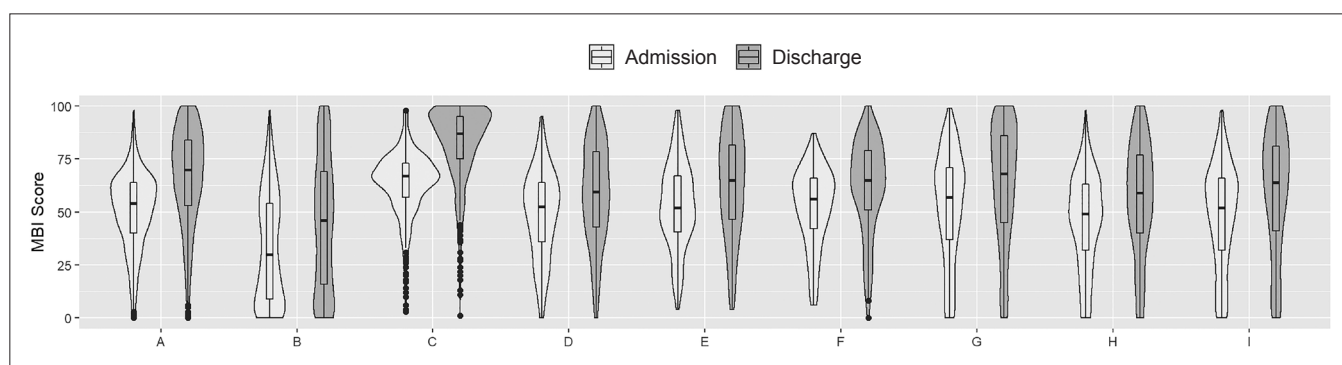


Fig. 2. Distribution of Modified Barthel Index on admission to and discharge from community hospital, stratified by admitting disease condition. (A) Injuries and fractures, (B) stroke, (C) musculoskeletal conditions, (D) cardiac conditions, (E) malignancy and palliative conditions, (F) falls, (G) acute exacerbation of chronic obstructive pulmonary disease, pneumonia and other lower respiratory tract infections, (H) other infections, and (I) others.

community hospital (median 32 days, IQR 23–46 vs 25 days, IQR 14–40; $P<0.001$), were less frail (median Frailty Risk Score 8.1, IQR 3.7–13.8 vs 10.8, IQR 6.0–17.4; $P<0.001$) and had fewer comorbidities (median CCI 2, IQR 0–4 vs 3, IQR 2–5; $P<0.001$). They had lower use of psychotropic medications (43.5% vs 52.0%, $P<0.001$), higher eGFR ($\geq 60\text{mL/min/1.73m}^2$: 75.6% vs 65.1%, $P<0.001$). Among this group, there was a higher proportion of those with normal level of albumin (22.6% vs 17.9%, $P<0.001$), blood urea (72.0% vs 61.5%, $P<0.001$), haemoglobin (23.9% vs 20.9%, $P<0.001$) and sodium levels (67.6% vs 66.1%, $P<0.001$), in addition to a higher RBC count (median 3.8, IQR 3.4–4.2 vs 3.7, IQR 3.3–4.1, $P<0.001$). Notably, a significantly higher proportion of patients whose discharge diagnosis at the acute hospital was musculoskeletal conditions had improved while those with other conditions did not.

Multivariable analysis

In multivariable regression analyses, age (65–74 years, odds ratio [OR] 0.97, 95% confidence interval [CI] 0.80–1.18; 75–84 years, OR 0.82, 95% CI 0.68–0.99; and ≥ 85 years, OR 0.63, 95% CI 0.51–0.78; with reference to <65 years), a history of dementia (OR 0.53, 95% CI 0.45–0.64), stroke (OR 0.72, 95% CI 0.62–0.84), psychotropic medication use during the acute hospital stay (OR 0.85, 95% CI 0.75–0.96), lower eGFR (30–59mL/min/1.73m² [OR 0.86, 95% CI 0.73–1.02], and $<30\text{mL/min/1.73m}^2$ [OR 0.48, 95% CI 0.36–0.63]), hypoalbuminaemia (mild [OR 0.80, 95% CI 0.69–0.94] and marked [OR 0.63, 95% CI 0.50–0.80]), and moderate to severe anaemia (OR 0.81, 95% CI 0.68–0.97) were associated with lower odds of improvement. However, higher MBI on admission (25–49 [OR 2.30, 95% CI 1.90–2.79], 50–74 [OR 1.83, 95% CI 1.51–2.21] and 75–90 [OR 1.20–2.01]

Table 2. Multivariable logistic regression analysis of epidemiological and clinical risk factors associated with functional improvement

Characteristics	Model 1		Model 2		Model 3		Model 4 (Final model)	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
Demographics								
Age category								
<65 years	Reference	<0.001	Reference	<0.001	Reference	<0.001	Reference	<0.001
65–74 years	0.88 (0.73–1.05)		0.94 (0.78–1.14)		0.93 (0.77–1.13)		0.97 (0.80–1.18)	
75–84 years	0.71 (0.59–0.85)		0.79 (0.66–0.95)		0.78 (0.65–0.94)		0.82 (0.68–0.99)	
≥85 years	0.48 (0.40–0.59)		0.60 (0.49–0.74)		0.58 (0.47–0.71)		0.63 (0.51–0.78)	
Female	1.11 (0.98–1.24)	0.090	1.05 (0.93–1.19)	0.396	1.05 (0.93–1.18)	0.434	1.09 (0.96–1.23)	0.185
Ethnicity								
Chinese	Reference	0.033	Reference	0.165	Reference	0.199	Reference	0.217
Malay	0.81 (0.63–1.04)		0.85 (0.66–1.09)		0.83 (0.65–1.07)		0.87 (0.67–1.12)	
Indian	0.76 (0.60–0.97)		0.80 (0.62–1.02)		0.82 (0.64–1.04)		0.79 (0.61–1.01)	
Others	0.81 (0.60–1.09)		0.88 (0.65–1.20)		0.89 (0.66–1.21)		0.94 (0.69–1.28)	
Details of hospital admission								
MBI score on admission category								
0–24	Reference	<0.001	Reference	<0.001	Reference	<0.001	Reference	<0.001
25–49	2.38 (1.98–2.85)		2.20 (1.83–2.65)		2.21 (1.84–2.67)		2.30 (1.90–2.79)	
50–74	2.23 (1.88–2.66)		1.80 (1.51–2.16)		1.79 (1.49–2.14)		1.83 (1.51–2.21)	
75–90	2.03 (1.60–2.57)		1.51 (1.18–1.93)		1.49 (1.16–1.91)		1.55 (1.20–2.01)	
91–99	0.89 (0.49–1.60)		0.62 (0.34–1.12)		0.59 (0.32–1.07)		0.64 (0.35–1.17)	
Diagnosis at discharge from acute care hospital								
Injuries and fractures	Reference	<0.001	Reference	<0.001	Reference	<0.001	Reference	<0.001
Stroke	0.60 (0.50–0.73)		0.75 (0.60–0.94)		0.73 (0.58–0.92)		0.70 (0.55–0.88)	
Musculoskeletal conditions	2.12 (1.69–2.65)		1.87 (1.48–2.37)		1.90 (1.50–2.41)		2.06 (1.61–2.64)	
Cardiac conditions	0.48 (0.35–0.67)		0.63 (0.45–0.89)		0.63 (0.44–0.88)		0.64 (0.45–0.91)	
Malignancy and palliative conditions	0.55 (0.39–0.76)		0.54 (0.36–0.79)		0.52 (0.35–0.78)		0.57 (0.38–0.85)	
Falls	0.55 (0.39–0.77)		0.65 (0.46–0.91)		0.64 (0.45–0.90)		0.57 (0.40–0.81)	
AE-COPD, pneumonia and other LRTIs	0.70 (0.57–0.85)		0.78 (0.63–0.97)		0.78 (0.63–0.97)		0.81 (0.65–1.01)	

Table 2. Multivariable logistic regression analysis of epidemiological and clinical risk factors associated with functional improvement (Cont'd)

Characteristics	Model 1			Model 2			Model 3			Model 4 (Final model)		
	OR (95% CI)	P		OR (95% CI)	P		OR (95% CI)	P		OR (95% CI)	P	
Other infections	0.51 (0.43–0.61)			0.62 (0.52–0.74)			0.62 (0.52–0.74)			0.66 (0.54–0.79)		
Others	0.50 (0.41–0.61)			0.53 (0.43–0.66)			0.53 (0.43–0.66)			0.55 (0.44–0.68)		
Comorbidities												
Frailty Risk Score category												
Low risk (<5)	-			Reference		0.058	Reference		0.175	Reference		0.270
Intermediate risk (5–15)	-			0.89 (0.76–1.03)			0.91 (0.78–1.06)			0.94 (0.80–1.10)		
High risk (>15)	-			0.80 (0.67–0.96)			0.84 (0.70–1.01)			0.86 (0.71–1.04)		
Patients with the following comorbidity												
Dementia	-			0.54 (0.45–0.64)		<0.001	0.54 (0.46–0.65)		<0.001	0.53 (0.45–0.64)		<0.001
Chronic liver disease	-			0.86 (0.68–1.08)		0.192	0.85 (0.67–1.07)		0.174	0.86 (0.68–1.09)		0.217
Diabetes mellitus	-			0.85 (0.75–0.96)		0.008	0.87 (0.77–0.99)		0.032	0.89 (0.78–1.01)		0.071
Renal disease	-			0.76 (0.66–0.87)		<0.001	0.76 (0.66–0.87)		<0.001	1.01 (0.84–1.20)		0.933
Tumour	-			0.95 (0.77–1.18)		0.658	0.96 (0.78–1.19)		0.714	1.08 (0.87–1.35)		0.487
Stroke	-			0.75 (0.64–0.86)		<0.001	0.75 (0.65–0.87)		<0.001	0.72 (0.6–0.84)		<0.001
Congestive heart failure/myocardial infarct	-			0.81 (0.7–0.94)		0.005	0.82 (0.71–0.96)		0.013	0.92 (0.79–1.08)		0.294
Medications prescribed												
Overall psychotropic medications use	-			-			0.87 (0.77–0.98)		0.023	0.85 (0.75–0.96)		0.009
No. of medication on discharge												
<9	-			-			Reference		0.024	Reference		0.132
9–11	-			-			0.81 (0.69–0.94)			0.83 (0.71–0.98)		
12–14	-			-			0.91 (0.77–1.08)			0.95 (0.80–1.13)		
>14	-			-			0.80 (0.67–0.96)			0.89 (0.74–1.08)		
Length of stay in community hospital	-			-			-			1.01 (1.01–1.01)		<0.001
Laboratory parameters												
eGFR												
≥60mL/min/1.73m ²	-			-			-			Reference		<0.001
30–59mL/min/1.73m ²	-			-			-			0.86 (0.73–1.02)		

Table 2. Multivariable logistic regression analysis of epidemiological and clinical risk factors associated with functional improvement (Cont'd)

Characteristics	Model 1			Model 2			Model 3			Model 4 (Final model)		
	OR (95% CI)	P		OR (95% CI)	P		OR (95% CI)	P		OR (95% CI)	P	
<30mL/min/1.73m ²	-	-		-	-		-	-		0.48 (0.36–0.63)		
Unknown	-	-		-	-		-	-		0.59 (0.25–1.38)		
Albumin												
Normal	-	-		-	-		-	-		Reference	0.001	
Mild hypoalbuminaemia	-	-		-	-		-	-		0.80 (0.69–0.94)		
Marked hypoalbuminaemia	-	-		-	-		-	-		0.63 (0.50–0.80)		
Unknown	-	-		-	-		-	-		0.89 (0.75–1.07)		
Haemoglobin												
Normal	-	-		-	-		-	-		Reference	0.038	
Mild anaemia	-	-		-	-		-	-		0.99 (0.85–1.16)		
Moderate to severe anaemia	-	-		-	-		-	-		0.81 (0.68–0.97)		
Unknown	-	-		-	-		-	-		1.54 (0.31–7.71)		
Sodium												
Normal	-	-		-	-		-	-		Reference	0.013	
Mild hyponatraemia	-	-		-	-		-	-		1.01 (0.88–1.16)		
Moderate/severe hyponatraemia	-	-		-	-		-	-		0.64 (0.45–0.93)		
Hypernatraemia	-	-		-	-		-	-		0.56 (0.27–1.14)		
Unknown	-	-		-	-		-	-		1.24 (0.99–1.55)		
Lymphocytes (10 ⁹ /L) category												
<1.5	-	-		-	-		-	-		Reference	0.550	
≥1.5	-	-		-	-		-	-		0.94 (0.84–1.06)		
Unknown	-	-		-	-		-	-		0.70 (0.15–3.14)		
Model assessment												
Log likelihood	-3642.4			-3569.1			-3560.7			-3464.5		
Likelihood-ratio test P value	-			<0.001			0.002			<0.001		
Area under receiver operating curve	0.6701			0.6936			0.6961			0.7240		

AE-COPD: acute exacerbation of chronic obstructive pulmonary disease; CI: confidence interval; eGFR: estimated glomerular filtration rate; LRTIs: lower respiratory tract infections; MBI: Modified Barthel Index; OR: odds ratio
The community hospital that the patient was admitted to was additionally adjusted in all the models (data not shown).

with 0–24 as reference) and longer length of stay at the community hospital (OR 1.01, 95% CI 1.01–1.01) were associated with improvement. Compared with patients admitted for injuries and fractures, patients admitted to community hospital for stroke (OR 0.70, 95% CI 0.55–0.88), cardiac conditions (OR 0.64, 95% CI 0.45–0.91), malignancy/palliative care (OR 0.57, 95% CI 0.38–0.85), falls (OR 0.57, 95% CI 0.40–0.81), AE-COPD/pneumonia/LRTIs (OR 0.81, 95% CI 0.65–1.01), other infections (OR 0.66, 95% CI 0.54–0.79), and all others (OR 0.55, 95% CI 0.44–0.68) were less likely to show improvement in the MBI band. In contrast, patients admitted for musculoskeletal disorders (OR 2.06, 95% CI 1.61–2.64) were more likely to improve (Table 2). Our final model (model 4) achieved an area under the receiver operating curve of 72.4% (fair predictive value).

Stratified analyses showed that history of dementia, history of stroke, psychotropic medication use, eGFR <60mL/min/1.73m² and Malay ethnicity were associated with a lower odds of improvement in patients who were admitted to the acute hospital with injuries/fractures. A history of dementia was also associated with lower odds of improvement among those admitted for stroke and other infections. A history of stroke was also associated with lower odds of improvement among those admitted for musculoskeletal conditions (Supplementary Table S1 in online Supplementary Material).

DISCUSSION

In this 3-year retrospective cohort study, we found that half (50.2%) of all patients discharged to a community hospital showed an improvement in MBI band after rehabilitation. Age determined functional improvement significantly in our study. This is consistent with a German study that reported a decrease in relative improvement on MBI scale with increasing age among stroke patients.²¹ A similar association was found in a study that assessed the functional capacity using the Functional Independence Measure (FIM).²²

We found that patients with musculoskeletal conditions had double the odds of improvement during their stay at the community hospital compared to patients admitted to the acute hospital for injuries. This is consistent with a study by Cook et al.²³ The study suggested that long-stay home care patients suffering from musculoskeletal disorders who received physiotherapy and occupational therapy had significantly increased odds of functional improvement.²³ Patients discharged with malignancy, falls, pneumonia and stroke had lower likelihood of improvement. This is consistent with a study conducted in 4 community hospitals in Singapore

where the median rehabilitation effectiveness was lower in stroke, pneumonia, cancer and falls patients than in patients admitted for fractures.²⁴ Nonetheless, many studies have showed that physical and psychosocial rehabilitation can improve symptom control, minimise disability, reduce recurrence of events, facilitate recovery and psychological well-being, and improve quality of life among patients in those groups.^{25–28}

The presence of comorbidities has an effect on the potential for functional improvement. Patients with a CCI score of >3 had a statistically significant lower odds of functional improvement by 16% compared to those with scores of ≤3 (results not shown), after adjustment. We observed that having dementia reduced the overall odds of improvement by nearly 50%. An Italian study conducted among elderly patients who were admitted to a rehabilitation unit after acute care hospitalisation reported that dementia was a significant determinant of mobility impairment (OR 3.45, 95% CI 2.39–4.37).²⁹ Similarly, a higher improvement in cognitive and motor subscales of FIM at discharge in post-hip fractured individuals aged ≥65 years without dementia compared to those with dementia was highlighted in a study performed in Australian public hospitals.³⁰ One possible reason for the lower rehabilitation effectiveness in dementia patients is a comparatively poorer adherence to the rehabilitation plan, or inability to perform rehabilitation exercises properly.³¹ It is important that motor ability and cognitive function are taken into consideration when designing rehabilitation plans. Our study, likewise, found that patients with a pre-existing history of stroke were less likely to improve—a finding consistent with previous studies.³² Furthermore, patients with severe stroke have been reported to show slower functional recovery compared to those with moderately severe stroke.^{33,34}

Psychotropic medication use during acute hospital stay was associated with lower odds of improvement in our study. This is similar to findings in a study among elderly hip fracture patients, which revealed that lower total and motor FIM gains were observed in psychotropic drug users.³⁵

Our finding of a significant dose-response relationship between eGFR and functional improvement agreed with observations made in a UK study, which described the correlation between eGFR at admission and improvement in Barthel Index score during rehabilitation.³⁶ Serum albumin collected at admission^{37,38} or after rehabilitation³⁹ among elderly stroke patients was previously reported as a predictor of functional outcome assessed by the Barthel Index. Consistent with these findings, our results suggested a dose-response relationship between

low serum albumin and the likelihood of functional improvement. We further observed that anaemia was a significant predictor of functional outcome. Chan and Ganasekaran suggested that anaemia could reduce rehabilitation efficacy and affect functional outcomes.⁴⁰ Furthermore, anaemic patients were found to encounter more complications compared to non-anaemic stroke patients who required a longer period of stay in the rehabilitation unit.^{40,41}

Similar to our findings among patients with principal diagnosis of injury/fracture, a Singapore study on rehabilitation effectiveness and rehabilitation efficiency in stroke patients showed that Malay ethnicity was an independent predictor of poorer rehabilitation outcomes.⁴² It is not clear why this should be so, but it may reflect residual confounding of biological factors that are associated with poorer improvement.

This study highlights that patient factors such as the presence of dementia; presence of markers of frailty such as anaemia and hypoalbuminaemia, and pre-existing conditions should be considered by physiotherapists and rehabilitation physicians when designing rehabilitation programmes. In addition, the reason for admission to the acute hospital is also important, and should be taken into account when developing personalised rehabilitation plan. It is possible that patients with multiple factors associated with lower odds of improvement will benefit from customised therapy that optimises the intensity or length of physiotherapy. Intervention studies are needed to establish this.

The strength of our study lies in the use of pragmatic evidence from a real-world setting in which patients with varying types of underlying conditions requiring community hospital stay and physical rehabilitation are included. MBI was assessed by trained healthcare professionals from community hospitals, thus minimising potential measurement error and outcome misclassification. Limitations include the use of MBI cut-offs that are not standardised. As our study population only comprises patients who received hospital-based rehabilitation, our findings may not be generalisable to individuals receiving home- or community-based rehabilitation programmes. We were unable to obtain potentially important social determinants of functional improvement, such as the availability of family and social support or being socially isolated. Indeed, social factors have been reported to be associated with functional decline among community-dwelling elderly.⁴³ The functional status data of patients prior to acute hospital admission was also

not available. Therefore, we cannot assess the extent of functional improvement to premorbid status as a consequence of rehabilitation in the community hospital.

In summary, we demonstrated that certain patient medical factors in relation to medical history and laboratory parameters, as well as the principal reason for admission to acute hospital were associated with functional improvement during the community hospital stay for extended care. Therapists may consider the presence of these high-risk factors in their patients when planning rehabilitation programmes, in order to maximise the likelihood of functional improvement and prevent complications arising from their disability.

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