

ORIGINAL ARTICLE

Functional Independence Measure Subtypes among Inpatients with Subacute Stroke: Classification via Latent Class Analysis

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Objectives: Using Functional Independence Measure (FIM) records, this study used latent class analysis (LCA) to clarify the structure of activities of daily living (ADL) status in patients following stroke. **Methods:** In this retrospective, single-center study, we extracted the medical records of patients with stroke who were admitted to a rehabilitation hospital in Japan between April 2018 and March 2020. LCA was used to determine classes of ADL status based on response patterns in FIM items converted from the original seven levels to three levels: Complete Dependence, FIM1–2; Modified Dependence, FIM3–5; Independence, FIM6–7. We compared the length of stay and discharge destinations among subgroups of patients with different ADL status at admission. **Results:** From 373 patients, 1592 FIM records were analyzed. These were classified into six ADL status classes based on “Complete Dependence,” “Modified Dependence,” and “Independence” in the motor and cognitive domains. Significant differences were observed among the six admission ADL subgroups for the length of stay (median values in patient subgroups based on admission ADL status: 126, 146, 90, 65, 44, and 29 days in the Motor Complete/Cognitive Complete, Motor Complete/Cognitive Modified, Motor Modified/Cognitive Modified, Motor Modified/Cognitive Independent, Motor Independent/Cognitive Modified, and Motor Independent/Cognitive Independent groups, respectively) and discharge destinations (patients discharged home: 27%, 62%, 81%, 92%, 95%, and 98%, respectively, and to acute care hospitals: 18%, 14%, 8%, 8%, 2%, and 2%, respectively). **Conclusions:** LCA successfully stratified ADL status in patients with stroke undergoing rehabilitation and may aid in determining an appropriate treatment regimen.

Key Words: discharge destination; length of stay; probability; prognosis; rehabilitation

INTRODUCTION

Studies on activities of daily living (ADL) are crucial for rehabilitation in patients with stroke. Previous studies on ADL have employed linear regression and outcome prediction methods with the goal of improving the quality of

therapeutic interventions and providing information that can aid patients in providing consent.^{1–4)} Additionally, the relationship between ADL ability at admission and important variables, such as discharge destination and length of stay, is critical for developing individualized treatment regimens and for management in hospitals and by insurance systems.

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However, few studies have addressed these aspects.

The primary scientific aim in most clinical trials is to identify the best treatment for a given disease, with any heterogeneity in patient characteristics or outcomes being viewed as an impediment to the research process.⁵⁾ However, precision medicine has attracted increased attention in recent years, utilizing patient heterogeneity to improve treatment decisions and ensure that the right treatment is given to the right patient at the right time.⁵⁾ As such, considering the heterogeneity of ADL status among patients with stroke is important when attempting to improve the efficacy of intervention.

The Functional Independence Measure (FIM) has been used in several studies related to ADL. FIM items are broadly classified into motor and cognitive items, and the total score and scores for each category (FIM-motor, FIM-cognition, and FIM-total) are often used as continuous variables. Evaluating item-level FIM scores is crucial when applying treatment regimens to individual patients. However, previous studies using Rasch analysis have demonstrated the relative difficulty of item-level FIM assessment.^{6,7)} Koyama *et al.*⁸⁾ investigated variability in the performance profiles of motor items by applying ordinal logistic modeling analysis using the FIM-motor score as the independent variable and the independence levels of single motor items as the dependent variables. Based on their study, clinicians can now assess which of the motor items should receive more intensive training as per the patient's FIM-motor score. Although studies have reported a relationship between a single motor item and the FIM-motor score, a similar relationship for FIM cognitive items has not been described. However, in stroke, where both higher brain and motor dysfunction serve as inhibitory factors, the relationship between motor and cognitive items is significant.⁹⁾

Latent class analysis (LCA) assumes that the sample of subjects includes a number of latent subgroups (latent classes) and aims to classify subjects into the same latent class based on homogeneous response patterns to variables of interest (category variables).^{10–12)} LCA is a form of unsupervised learning without predetermined classifications or class characteristics. When there is a relationship between observed variables (manifest variables), LCA assigns a subject to a latent class (latent variable), and the relationship disappears within the class. At this time, the law of “local independence” is established, and subjects within the same latent class are considered homogeneous based on observed variables. Although it was first introduced for use in social sciences research, LCA has recently attracted attention in healthcare fields^{10,12)} and has been applied in studies across

various disciplines.^{13–15)} We hypothesized that LCA could be used to classify FIM records into ADL subgroups that consider both motor and cognitive items based on the pattern of responses to FIM items, which are originally represented as ordinal categorical variables.

Therefore, in the current study, we aimed to characterize the structure of ADL status among inpatients with subacute stroke by using LCA to classify FIM records based on the responses to both cognitive and motor items. Furthermore, we applied these classifications to compare significant variables such as the length of stay and discharge destination based on ADL status at the time of admission.

MATERIALS AND METHODS

This retrospective, single-center study was performed at Saiseikai Higashikanagawa Rehabilitation Hospital in Yokohama, Japan. Because this study used medical records containing real-world data, we followed the Reporting of studies Conducted using Observational Routinely collected Data (RECORD) checklist.¹⁶⁾ We retrospectively enrolled 613 patients with cerebrovascular disease who were admitted to the hospital between April 2018 and March 2020. From these patients, we selected those who met the following inclusion criterion: ischemic or hemorrhagic stroke diagnosed on neuroradiological examination (i.e., computed tomography or magnetic resonance imaging). We excluded those who met one or more of the following exclusion criteria: subarachnoid hemorrhage, subdural hematoma, cerebellar and brainstem lesions, comorbidity of acute locomotor disorders, and hospitalization for less than 1 day. These inclusion and exclusion criteria were based on the criteria used in a previous study⁸⁾; however, patients with a history of stroke were not excluded to account for the actual situation in research facilities in Japan, in which patients with recurrent stroke are relatively common. As a result, the number of patients entered into the final database determined the sample size.

In accordance with the procedures outlined by the Japanese Health Insurance System (2018–2020), patients were referred from acute care medical services within 60 days after the stroke occurred and subsequently could receive inpatient care in our rehabilitation hospital for up to 180 days. During long-term hospitalization, they received physical therapy, occupational therapy, and speech therapy for a total of 120–180 min every day. Similar clinical settings are used across rehabilitation hospitals in Japan.

Measures

To evaluate ADL status, the FIM¹⁷⁾ was administered at the time of admission, at monthly intervals, and at the time of discharge. The FIM is one of the most widely used, reliable, and valid tools for evaluating ADL status after stroke.^{6,7,18–20)} The FIM consists of 13 motor items (eating, grooming, bathing, dressing the upper body, dressing the lower body, toileting, bladder control, bowel control, transfer to bed/chair/wheelchair, transfer to toilet, transfer to tub/shower, walking or wheelchair use, and climbing stairs) and five cognitive items (comprehension, expression, social interaction, problem-solving, and memory). Each item is evaluated on a seven-point scale (1, total assistance; 2, maximal assistance; 3, moderate assistance; 4, minimal assistance; 5, supervision; 6, modified independence; 7, complete independence). In the present study, the FIM assessments were performed by the nurse treating the patient. In LCA, collapsing multiple response options into two or three options makes it easier to interpret the class solution.²¹⁾ Therefore, in this study, FIM response levels were grouped into three levels (1–2, Complete Dependence; 3–5, Modified Dependence; 6–7: Independence) to interpret the major features of each class in accordance with previously described methods.²²⁾

In addition to obtaining scores for the individual FIM items, the total-summation score (FIM-total), subtotal-summation score of motor components (FIM-motor), and subtotal-summation score of cognitive components (FIM-cognition) were extracted on a seven-point scale. Moreover, data related to the length of stay (days) and discharge destination (home, nursing home/long-term hospital, acute care hospital in case of deterioration of the patient's condition, or other rehabilitation facilities) were extracted as important variables.

Statistical Analysis

To determine the ability of the FIM to capture ADL status rather than classify patients, we analyzed multiple FIM records under the assumption of independent and identical distribution. All FIM records were classified into latent classes (latent ADL status) based on item responses using LCA, which allowed for assumption regarding the order of the categorical variables observed in this study.²³⁾ FIM records were classified according to responses to the ordinal categorical variables that were integrated into a three-level classification system.

The number of classes was selected based on the following selection criteria while favoring the most parsimonious model^{12,21,24,25)}: (a) statistical measures of model fit, (b) number of subjects in the class, (c) certainty of individual

membership, and (d) interpretability. The model fit indices relied on the Bayesian information criterion (BIC) and Akaike information criterion (AIC), decreases in which indicated improvements in the model. Based on these criteria, the number of FIM records should be 5% or more for each class, and the certainty of individual membership should have an entropy value of 0.8 or greater. Interpretability should also be confirmed by several psychiatrists based on the class characteristics. We interpreted the characteristics of the classes using the item-response probability output of the LCA. These probabilities indicate the probability that a FIM record in a class will respond to the observed measure (i.e., the FIM items). In this study, the profile of item-response probabilities was visualized using a heat map for the three FIM levels. Unlike cluster analysis, in which the subjects are completely classified into one class, LCA calculates the probability of each subject being assigned to each class. In this study, patients had different numbers of FIM records depending on their length of stay. Therefore, the probability of belonging to each class was given for each FIM record that the patient had completed at some point of evaluation. For notational purposes, G represents the latent class including the FIM record (g ; 1, ..., G), N represents the patient (n ; 1, ..., N), J represents the time of evaluation (j ; 1, ..., J), and $X1$ – $X18$ represent the responses to the 18 items of the FIM. The probability that a FIM record at time j in patient n belongs to the latent class g is represented by $\hat{\pi}_{gnj}^{G|NJ}$ (see Equation 1 and Fig. 1):

$$\hat{\pi}_{gnj}^{G|NJ} = P(G_{nj} = g | X1_{nj}, X2_{nj}, \dots, X18_{nj}) \quad (1)$$

Using the probability of belonging to each class (Equation 1) given to all FIM records as a weight, the total FIM score (FIM-motor, FIM-cognition, and FIM-total) was calculated for each class. F_{nj} represents the total FIM score of the FIM record at time j in patient n .

$$\text{Mean total FIM score in class } g = \frac{\sum_{j=1}^J \sum_{n=1}^N (\hat{\pi}_{gnj}^{G|NJ} \times F_{nj})}{\sum_{j=1}^J \sum_{n=1}^N \hat{\pi}_{gnj}^{G|NJ}} \quad (2)$$

We then compared the length of stay and discharge destination according to the class of ADL status of the patients at admission. FIM records at admission were extracted from all FIM records, following which the length of stay in each subgroup was calculated using the probability (Equation 1) as a weight. Differences among the groups were compared

| | Time of admission (j=1) | One month (j=2) | ... | Time j (j=j) |
|------------------|----------------------------|--------------------------|-----|--------------------------|
| Class 1 (g=1) | $\hat{\pi}_{1n1}^{G NJ}$ | $\hat{\pi}_{1n2}^{G NJ}$ | ... | $\hat{\pi}_{1nj}^{G NJ}$ |
| Class 2 (g=2) | $\hat{\pi}_{2n1}^{G NJ}$ | $\hat{\pi}_{2n2}^{G NJ}$ | ... | $\hat{\pi}_{2nj}^{G NJ}$ |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| Class G (g=G) | $\hat{\pi}_{Gn1}^{G NJ}$ | $\hat{\pi}_{Gn2}^{G NJ}$ | ... | $\hat{\pi}_{Gnj}^{G NJ}$ |

Fig. 1. Probability that the FIM record at time j in patient n belongs to the latent class g .

using the Steel–Dwass test (significance level, $\alpha=0.05$) in consideration of multiplicity. In Equation 3, L_n represents the length of stay in patient n .

*Mean Length of stay in the subgroup
belonging to class g at admission*

$$= \frac{\sum_{n=1}^N (\hat{\pi}_{gn1}^{G|NJ} \times L_n)}{\sum_{n=1}^N \hat{\pi}_{gn1}^{G|NJ}} \quad (3)$$

Similarly, the discharge destinations of patient subgroups based on ADL status at admission were examined using the chi-square test (significance level, $\alpha=0.05$). Finally, using the characteristics of the class (ADL status), we suggested a treatment regimen for that ADL status at each time point. Additionally, we utilized findings regarding the length of stay and discharge destination for each ADL status at admission to update the suggested treatment regimen. All statistical analyses were conducted using LatentGOLD®5.1.0 (Statistical Innovations, Arlington, MA, USA) and JMP® 15.1.0 (SAS Institute, Cary, NC, USA). The heat map was drawn using Python 3.9.0 (Python Software Foundation, DE, USA). LCA was performed using a dataset that excluded FIM records with missing values.

Ethics

This study was approved by the Saiseikai Higashikanagawa Rehabilitation Hospital Ethics Committee (No. 21–04). Informed consent was obtained using the opt-out method, and information on this study was published on the hospital bulletin board and website.

RESULTS

Patients

Based on the inclusion and exclusion criteria, 373 patients were selected for this study (Fig. 2). Of 1626 extracted FIM records, 34 were excluded because of missing values for FIM items, leaving 1592 FIM records for analysis. The characteristics of the study population are summarized in Table 1. The patients varied widely in terms of age, lesion site, and lesion side, and the study population contained a larger proportion of men than women. The population included 70 patients with a history of stroke and 48 with a history of locomotor disorders.

Classification

A total of 1592 FIM records were classified into latent classes (ADL status) using LCA, based on combinations of the 18 FIM items. To select the best latent class solution, we examined latent class models with one to seven classes. Table 2 lists the model fit indices. The difference in the BIC/AIC fit between models indicated that the improvements in model fit with each additional class began to slow at the six-class model. Hence, based on reductions in BIC and AIC and other confirmed criteria after verifying the interpretability of the class characteristics with two physiatrists, we selected the six-class model for this study.

Table 3 shows the proportion of FIM records belonging to each class (class size), as well as the item-response probabilities of the FIM items within each class; for example, the class size of class 1 was 0.16 (254.7 records, $1592 \times 0.16 = 254.7$),



Fig. 2. Flowchart showing the scheme used for patient selection.

and the ‘probability of independence in eating’ within class 1 was 0.02 (5.1 of 254.7 records of class 1 indicating independence, $254.7 \times 0.02 = 5.1$). **Figure 3** shows a heat map of the item-response probabilities listed in **Table 3**. As a general trend, independence improved from class 1 to class 6. Items such as eating, grooming, and bladder and bowel control, for which most responses indicated independence (FIM6–7), could be achieved relatively easily. Conversely, items such as transfer to the tub/shower and climbing stairs, for which most responses indicated complete dependence (FIM1–2), were more difficult to achieve. **Table 4** presents the data for the total FIM scores of each ADL status according to all FIM records. When assessing the total FIM scores, we observed that the FIM-motor and FIM-total scores of each class were arranged in order, whereas the FIM-cognition scores were arranged differently.

As shown in the heat map in **Fig. 3**, class 1 responded to most motor and cognitive items with “Complete Dependence”; therefore, we referred to this ADL status as “Motor-Complete Dependence, Cognition-Complete Dependence” (MCCC). MCCC tended to be completely dependent for general FIM items but exhibited improvements in motor items such as eating, grooming, and transfer to bed/chair/wheelchair. Similarly, in the assessments of cognitive items, we observed improvements in comprehension, expression, and social interaction.

Class 2 responded to most of the motor items with “Complete Dependence” and to most of the cognitive items with “Modified Dependence.” Therefore, we referred to this ADL status as “Motor-Complete Dependence, Cognition-Modified Dependence” (MCCM).

Class 3 responded to most motor and cognitive items with

Table 1. Patient characteristics

| Patient characteristic | | Total n=373 |
|------------------------------|-------------------------------------|-------------|
| Sex | Female | 115 |
| Age, years | Median (IQR) | 70 (57–78) |
| Lesion type | Hemorrhage | 154 |
| | Infarction | 215 |
| | Infarction with hemorrhage | 4 |
| Lesion side | Left | 201 |
| | Right | 155 |
| | Both | 17 |
| Acute treatment | Operative | 67 |
| Previous stroke | (+) | 70 |
| Previous locomotor disorders | (+) | 48 |
| Lesion site | Internal carotid artery | 15 |
| | Anterior cerebral artery | 8 |
| | Middle cerebral artery | 66 |
| | Posterior cerebral artery | 3 |
| | Frontal lobe | 18 |
| | Parietal lobe | 12 |
| | Temporal lobe | 14 |
| | Occipital lobe | 8 |
| | Corona radiata | 30 |
| | Thalamus | 56 |
| | Basal ganglion and internal capsule | 113 |
| | Others | 15 |
| | Combined lesions | 8 |
| | Disseminated | 4 |
| Missing value | 3 | |

IQR, interquartile range.

Table 2. Model fit indices of the latent class analysis of 18 FIM items

| | BIC | AIC | df | Entropy | Δ BIC | Δ AIC |
|---------|--------|--------|------|---------|--------------|--------------|
| 1-Class | 58,717 | 58,523 | 1556 | 1.00 | - | - |
| 2-Class | 41,168 | 40,873 | 1537 | 0.98 | 17,549 | 17,650 |
| 3-Class | 35,491 | 35,093 | 1518 | 0.97 | 5677 | 5781 |
| 4-Class | 34,078 | 33,578 | 1499 | 0.95 | 1413 | 1515 |
| 5-Class | 33,110 | 32,508 | 1480 | 0.95 | 968 | 1070 |
| 6-Class | 32,534 | 31,830 | 1461 | 0.95 | 576 | 678 |
| 7-Class | 32,024 | 31,218 | 1442 | 0.94 | 510 | 612 |

“Modified Dependence.” Therefore, we referred to this ADL status as “Motor-Modified Dependence, Cognition-Modified Dependence” (MMCM). In the detailed evaluation of response characteristics, modified dependence was generally common; however, independence was observed for motor items such as eating, bladder control, and bowel control.

Class 4 responded to most of the motor items with “Modi-

fied Dependence” and to most of the cognitive items with “Independence.” Therefore, we referred to this ADL status as “Motor-Modified Dependence, Cognition-Independence” (MMCI). In a detailed evaluation of responses to FIM items, the findings for motor items were similar to those observed in MMCM; however, an increase in independence was noted, especially in eating, grooming, bladder control, and

Table 3. Class response probability across three levels for each FIM item

| FIM item | Grouped response | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | Class 6 | Total |
|--------------------------------------|---------------------|---------|---------|---------|---------|---------|---------|-------|
| | | MCCC | MCCM | MMCM | MMCI | MICM | MICI | |
| Eating | Class size | 0.16 | 0.11 | 0.22 | 0.13 | 0.10 | 0.28 | 1.00 |
| | Independence | 0.02 | 0.15 | 0.33 | 0.80 | 0.87 | 0.98 | 0.56 |
| | Modified Dependence | 0.40 | 0.67 | 0.60 | 0.20 | 0.13 | 0.02 | 0.31 |
| | Complete Dependence | 0.58 | 0.18 | 0.07 | 0.00 | 0.00 | 0.00 | 0.13 |
| Grooming | Independence | 0.00 | 0.00 | 0.08 | 0.46 | 0.85 | 0.98 | 0.45 |
| | Modified Dependence | 0.21 | 0.69 | 0.89 | 0.54 | 0.15 | 0.02 | 0.39 |
| | Complete Dependence | 0.79 | 0.31 | 0.03 | 0.00 | 0.00 | 0.00 | 0.16 |
| Bathing | Independence | 0.00 | 0.00 | 0.00 | 0.03 | 0.48 | 0.65 | 0.24 |
| | Modified Dependence | 0.06 | 0.31 | 0.87 | 0.94 | 0.52 | 0.35 | 0.51 |
| | Complete Dependence | 0.94 | 0.69 | 0.13 | 0.03 | 0.00 | 0.00 | 0.25 |
| Dressing the upper body | Independence | 0.00 | 0.00 | 0.02 | 0.15 | 0.80 | 0.97 | 0.38 |
| | Modified Dependence | 0.13 | 0.20 | 0.90 | 0.84 | 0.20 | 0.03 | 0.38 |
| | Complete Dependence | 0.87 | 0.80 | 0.08 | 0.01 | 0.00 | 0.00 | 0.24 |
| Dressing the lower body | Independence | 0.00 | 0.00 | 0.02 | 0.11 | 0.77 | 0.96 | 0.37 |
| | Modified Dependence | 0.04 | 0.07 | 0.70 | 0.82 | 0.23 | 0.04 | 0.31 |
| | Complete Dependence | 0.96 | 0.93 | 0.28 | 0.07 | 0.00 | 0.00 | 0.32 |
| Toileting | Independence | 0.00 | 0.00 | 0.02 | 0.27 | 0.93 | 0.99 | 0.42 |
| | Modified Dependence | 0.08 | 0.05 | 0.78 | 0.72 | 0.07 | 0.01 | 0.29 |
| | Complete Dependence | 0.92 | 0.95 | 0.20 | 0.01 | 0.00 | 0.00 | 0.29 |
| Bladder control | Independence | 0.00 | 0.02 | 0.23 | 0.71 | 0.94 | 0.98 | 0.52 |
| | Modified Dependence | 0.03 | 0.14 | 0.31 | 0.22 | 0.06 | 0.02 | 0.13 |
| | Complete Dependence | 0.97 | 0.84 | 0.46 | 0.07 | 0.00 | 0.00 | 0.35 |
| Bowel control | Independence | 0.00 | 0.05 | 0.34 | 0.88 | 0.92 | 0.99 | 0.57 |
| | Modified Dependence | 0.05 | 0.25 | 0.40 | 0.11 | 0.08 | 0.01 | 0.15 |
| | Complete Dependence | 0.95 | 0.70 | 0.26 | 0.01 | 0.00 | 0.00 | 0.28 |
| Transfer to bed/ chair/wheelchair | Independence | 0.00 | 0.00 | 0.01 | 0.23 | 0.86 | 0.99 | 0.40 |
| | Modified Dependence | 0.38 | 0.44 | 0.99 | 0.77 | 0.14 | 0.01 | 0.44 |
| | Complete Dependence | 0.62 | 0.56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |
| Transfer to toilet | Independence | 0.00 | 0.00 | 0.00 | 0.22 | 0.89 | 0.99 | 0.40 |
| | Modified Dependence | 0.24 | 0.29 | 0.99 | 0.78 | 0.11 | 0.01 | 0.40 |
| | Complete Dependence | 0.76 | 0.71 | 0.01 | 0.00 | 0.00 | 0.00 | 0.20 |
| Transfer to tub/ shower | Independence | 0.00 | 0.00 | 0.02 | 0.03 | 0.32 | 0.49 | 0.18 |
| | Modified Dependence | 0.06 | 0.02 | 0.51 | 0.56 | 0.64 | 0.49 | 0.40 |
| | Complete Dependence | 0.94 | 0.98 | 0.47 | 0.41 | 0.04 | 0.02 | 0.42 |
| Walking or wheelchair use | Independence | 0.00 | 0.00 | 0.18 | 0.34 | 0.70 | 0.87 | 0.40 |
| | Modified Dependence | 0.15 | 0.15 | 0.55 | 0.53 | 0.28 | 0.13 | 0.30 |
| | Complete Dependence | 0.85 | 0.85 | 0.27 | 0.13 | 0.02 | 0.00 | 0.30 |
| Stairs | Independence | 0.00 | 0.00 | 0.02 | 0.03 | 0.31 | 0.47 | 0.17 |
| | Modified Dependence | 0.05 | 0.01 | 0.39 | 0.45 | 0.60 | 0.49 | 0.36 |
| | Complete Dependence | 0.95 | 0.99 | 0.59 | 0.52 | 0.09 | 0.04 | 0.47 |
| Comprehension | Independence | 0.00 | 0.31 | 0.12 | 0.91 | 0.24 | 0.99 | 0.48 |
| | Modified Dependence | 0.38 | 0.67 | 0.80 | 0.09 | 0.73 | 0.01 | 0.40 |
| | Complete Dependence | 0.62 | 0.02 | 0.08 | 0.00 | 0.03 | 0.00 | 0.12 |

Table 3. (continued)

| FIM item | Grouped response | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | Class 6 | Total |
|--------------------|---------------------|---------|---------|---------|---------|---------|---------|-------|
| | | MCCC | MCCM | MMCM | MMCI | MICM | MICI | |
| Expression | Independence | 0.02 | 0.42 | 0.21 | 0.95 | 0.36 | 0.93 | 0.52 |
| | Modified Dependence | 0.39 | 0.54 | 0.66 | 0.05 | 0.58 | 0.07 | 0.35 |
| | Complete Dependence | 0.59 | 0.04 | 0.13 | 0.00 | 0.06 | 0.00 | 0.13 |
| Social interaction | Independence | 0.01 | 0.51 | 0.43 | 0.93 | 0.65 | 0.99 | 0.62 |
| | Modified Dependence | 0.41 | 0.47 | 0.54 | 0.07 | 0.34 | 0.01 | 0.28 |
| | Complete Dependence | 0.58 | 0.02 | 0.03 | 0.00 | 0.01 | 0.00 | 0.10 |
| Problem-solving | Independence | 0.00 | 0.09 | 0.01 | 0.56 | 0.07 | 0.90 | 0.35 |
| | Modified Dependence | 0.01 | 0.85 | 0.70 | 0.44 | 0.85 | 0.10 | 0.42 |
| | Complete Dependence | 0.99 | 0.06 | 0.29 | 0.00 | 0.08 | 0.00 | 0.23 |
| Memory | Independence | 0.00 | 0.20 | 0.08 | 0.76 | 0.25 | 0.98 | 0.45 |
| | Modified Dependence | 0.07 | 0.74 | 0.75 | 0.24 | 0.70 | 0.02 | 0.36 |
| | Complete Dependence | 0.93 | 0.06 | 0.17 | 0.00 | 0.05 | 0.00 | 0.19 |

bowel control.

Class 5 responded to most of the motor items with “Independence” and to most of the cognitive items with “Modified Dependence.” Therefore, we referred to this ADL status as “Motor-Independence, Cognition-Modified Dependence” (MICM). In the detailed evaluation of responses to FIM items, independence was generally common in most of the motor items, but modified dependence remained in bathing, transfer to tub/shower, and climbing stairs. Modified dependence was generally common for cognitive items such as comprehension, expression, problem-solving, and memory.

Class 6 responded to most of the motor and cognitive items with “Independence.” Therefore, we referred to this ADL status as “Motor-Independence, Cognition-Independence” (MICI). In the detailed evaluation of responses to FIM items, independence was generally common; however, modified dependence remained in bathing, transfer to tub/shower, and climbing stairs.

Length of Stay and Discharge Destination

Table 5 shows the data related to the length of stay for each patient subgroup according to ADL status (class 1–6) at admission, while **Table 6** shows the data related to the discharge destination. Patients belonging to MCCC at the time of admission are represented as MCCC_a, and the same convention was used to designate the other subgroups. In the MCCC_a subgroup, 27% of patients achieved home discharge, and the median length of stay was 126 days; 18% of patients were transferred to an acute care hospital because of unfavorable outcomes. In the MCCM_a subgroup, 62% of patients achieved home discharge, and the median length of stay was

146 days. In the MMCM_a subgroup, 81% of patients achieved home discharge, and the median length of stay was 90 days. In the MMCI_a subgroup, 92% of patients achieved home discharge, and the median length of stay was 65 days. In the MICM_a subgroup, 95% of patients achieved home discharge, and the median length of stay was 44 days. In the MICI_a subgroup, 98% of patients achieved home discharge, and the median length of stay was 29 days. Comparisons indicated that greater independence was associated with a relatively shorter length of stay (although this trend was reversed between the MCCC_a and MCCM_a subgroups) and that the length of stay differed significantly among the subgroups, except between MCCC_a and MCCM_a, MMCM_a and MMCI_a, and MMCI_a and MICM_a (Steel–Dwass test, MCCC_a–MCCM_a, $P=0.7005$; MMCM_a–MMCI_a, $P=0.0526$; MMCI_a–MICM_a, $P=0.511$; MICM_a–MICI_a, $P=0.0052$; MCCC_a–MMCM_a, $P=0.0163$; MMCM_a–MICM_a, $P=0.0007$; others, $P<0.0001$). The mean length of stay was smaller than the median in the MCCC_a and MCCM_a subgroups and higher than the median in the other classes. Furthermore, the discharge destinations differed significantly among the subgroups [$\chi^2(15)=149.32$; $P<0.0001$]: the proportion of patients in the MCCC_a subgroup that were discharged to home was small and the proportion discharged to an acute care hospital was large when compared with the other subgroups.

DISCUSSION

In this study, we characterized latent ADL status (class) by classifying FIM records based on response patterns to motor and cognitive items. FIM records were then classified into

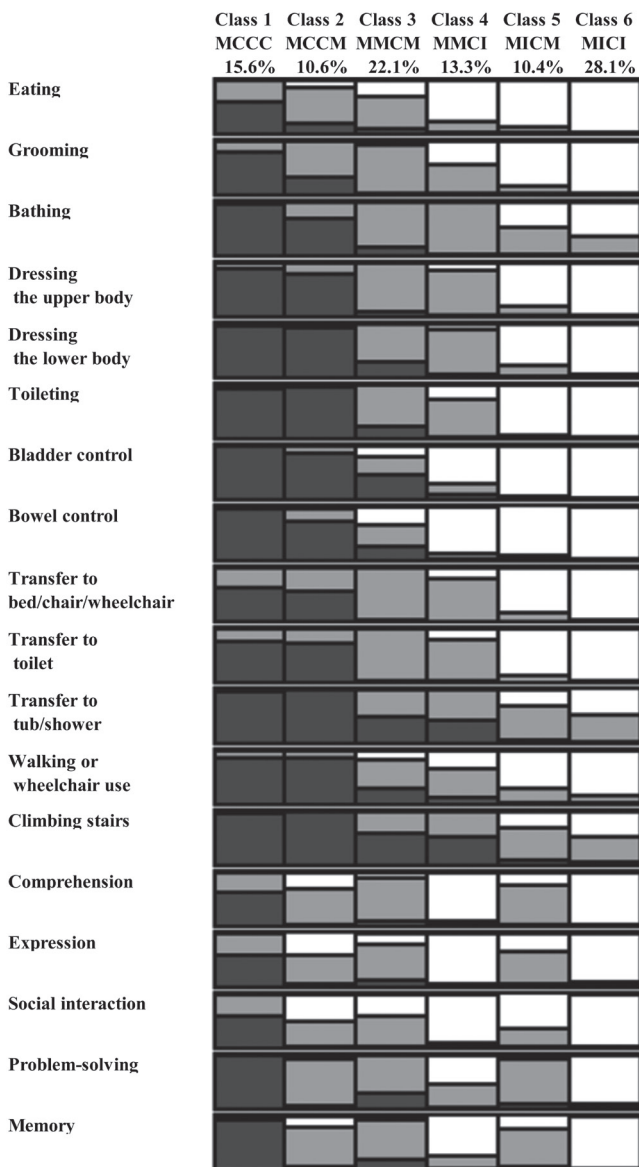


Fig. 3. Heat map of response probability for the 18 FIM items. Independence, white; Modified dependence, light gray; Complete dependence, dark gray.

six latent classes of ADL status based on patterns of complete dependence, modified dependence, and independence in the motor and cognitive domains. To our knowledge, this is the first study to utilize LCA to stratify ADL patterns based on FIM results in patients with stroke. As a result, we were unable to compare these patterns with those obtained using similar methods. However, the response probability for FIM items indicated that items such as eating, grooming, and bladder and bowel control were relatively easy, whereas items such as transfer to the tub/shower and climbing stairs were more difficult. This finding is consistent with that of

a previous study that utilized a different method.⁸⁾ In the analysis of the total FIM score, the order in which the classes were arranged was different depending on whether the value represented the FIM-total, FIM-motor, or FIM-cognition score, suggesting the multidimensionality of the FIM. Therefore, LCA represents an appropriate strategy given the multidimensional nature of the FIM.²⁶⁾ Furthermore, our findings indicated that the length of stay and discharge destination differed depending on the subgroup into which patients were categorized based on ADL status at admission. In the Japanese Health Insurance System, the optimal length of stay is based on the classification of diseases, and criteria such as the optimal proportion of discharge to home are set for facilities. This study suggests the necessity and possibility of setting different recommended values that focus on ADL status at admission. In addition, further studies are required to consider socio-environmental factors such as the presence of support at home, living with others, and marital status. These factors were reported as crucial for the consideration of home discharge in a previous systematic review²⁷⁾ and in another Japanese study.²⁸⁾ The paragraphs below include suggestions for the selection of treatment regimens based on the latent ADL status and patient subgroups according to ADL status at admission.

MCCC responded to the motor and cognitive items with “Complete Dependence”; however, higher levels of independence were seen in eating, grooming, and transfer activities, which was consistent with the findings of previous studies showing that these activities are less difficult.⁸⁾ Additionally, MCCC showed improved independence in comprehension, expression, and social interaction in cognitive items. Considering the interventions employed at rehabilitation hospitals in Japan, promoting interactions with other patients and staff (e.g., in the cafeteria or in common areas) and group exercise may lead to improvements in cognitive items and FIM scores in these patients. In MCCC, a patient subgroup that belonged to MCCC at the time of admission, the proportion of discharge to home was 27% and the median length of stay was 126 days; therefore, an intervention plan that considers the discharge destination from an early stage is important. Although the overall proportion of discharge to an acute care hospital in this study was 10%, the corresponding proportion in the MCCC subgroup was 18%. In a study of stroke patients admitted to rehabilitation hospitals in Japan, Tokisato et al. noted that 6.9% were transferred to acute care hospitals.²⁹⁾ In the USA, Stineman et al. reported that 9.1% of patients were transferred from stroke rehabilitation hospitals to acute care hospitals.³⁰⁾ In this study, the overall proportion

Table 4. Total FIM scores in each class

| | | Class 1 | Class 2 | Class 3 | Class 4 | Class 5 | Class 6 |
|---------------|--------|----------|----------|----------|----------|-----------|------------|
| | | MCCC | MCCM | MMCM | MMCI | MICM | MICI |
| FIM-motor | Mean | 20.0 | 26.3 | 47.5 | 60.7 | 79.1 | 83.8 |
| | Median | 18 | 26 | 48 | 62 | 79 | 85 |
| | (IQR) | (13, 25) | (21, 32) | (40, 54) | (56, 67) | (73, 87) | (80, 89) |
| FIM-cognition | Mean | 10.1 | 23.6 | 20.7 | 30.9 | 24.7 | 33.3 |
| | Median | 10 | 24 | 21 | 31 | 26 | 34 |
| | (IQR) | (7, 13) | (20, 27) | (17, 25) | (29, 33) | (23, 27) | (32, 35) |
| FIM-total | Mean | 30.0 | 49.9 | 68.2 | 91.6 | 103.8 | 117.2 |
| | Median | 30 | 49 | 68 | 92 | 104 | 118 |
| | (IQR) | (22, 37) | (44, 56) | (60, 76) | (86, 97) | (99, 112) | (112, 123) |

Table 5. Length of stay in each patient subgroup according to ADL class at admission

| | MCCCa | MCCMa | MMCMa | MMCIa | MICMa | MICIa | Total |
|------------|---------------|----------------|--------------|-------------|-------------|-------------|-------------|
| Class size | 87.9 | 70.7 | 72.2 | 51.9 | 38.9 | 51.4 | 373 |
| Mean | 119.8 | 133.6 | 96.1 | 75.6 | 61.2 | 34.8 | 93.8 |
| (95% CI) | (110.9–128.6) | (123.72–143.4) | (86.4–105.9) | (64.1–87.1) | (47.9–74.5) | (23.2–46.3) | (88.4–99.3) |
| Median | 126 | 146 | 90 | 65 | 44 | 29 | 91 |
| (IQR) | (78, 166) | (109, 168) | (64, 127) | (44, 106) | (29, 93) | (21, 37) | (44, 141) |

Data given in days.

CI, confidence interval.

Table 6. Discharge destination in each patient subgroup according to ADL class at admission

| | MCCCa | MCCMa | MMCMa | MMCIa | MICMa | MICIa | Total |
|-----------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-------|
| | Freq. (χ^2) | Freq. (χ^2) | Freq. (χ^2) | Freq. (χ^2) | Freq. (χ^2) | Freq. (χ^2) | Freq. |
| Home | 24.1 (22.8) | 43.5 (0.7) | 58.3 (1.2) | 47.7 (3.6) | 36.9 (3.5) | 50.4 (5.8) | 261 |
| Nursing home, long-term hospital | 43.9 (46.8) | 17.1 (1.3) | 6.9 (3.1) | 0.2 (9.3) | 1.0 (5.4) | 0.0 (9.5) | 69 |
| Acute care hospital | 16.0 (5.5) | 10.0 (1.1) | 6.0 (0.2) | 4.0 (0.3) | 1.0 (2.3) | 1.0 (3.4) | 38 |
| Other rehabilitation facilities | 4.0 (6.7) | 0.0 (0.9) | 1.0 (0) | 0.0 (0.7) | 0.0 (0.5) | 0.0 (0.7) | 5 |
| Discharged to home | 27% | 62% | 81% | 92% | 95% | 98% | 70% |
| Discharged to acute care hospital | 18% | 14% | 8% | 8% | 2% | 2% | 10% |

Freq., frequency.

of patients discharged to acute care hospitals was similar; however, when patients were classified by ADL status at the time of admission, the proportion reached 18% in the MCCCa group. This result suggests that close attention must be paid to clinical deterioration in patients classified as MCCCa.

MCCM responded to most of the motor items with “Com-

plete Dependence” and to most of the cognitive items with “Modified Dependence.” Although ADL status was better among the MCCM than the MCCC, the length of stay was longer in the MCCMa than in the MCCCa group. Unlike in other subgroups, the mean value for the length of stay in both the MCCCa and MCCMa groups was smaller than the

median. This indicates the presence of outliers with shorter lengths of stay. It was considered that patients with severe conditions but with a short length of stay would have been discharged to an acute care hospital because of clinical deterioration. In fact, there were several acute care transfers in the MCCCa and MCCMa groups (especially in the MCCCa group, which may have resulted in shortened length of stay). Alternatively, the length of stay may have been extended because the proportion of discharge to home was higher in the MCCMa group (62%) than in the MCCCa group (27%), and the preparation for home discharge required more time for patients in the MCCMa group. These findings indicate that patients in both the MCCCa and MCCMa groups should be monitored for clinical deterioration, and that systematic support should be provided from an early stage while considering the discharge destination and length of stay.

MMCM responded to most of the motor and cognitive items with “Modified Dependence.” Considering that the MMCM generally showed improved independence for motor items, treatment in this class should focus on expansion of ADL function (e.g., providing guidance to the toilet under assistance). However, when attempting to increase independence for motor-related items, the risk of falls should be carefully evaluated. Previous studies have indicated that unilateral spatial neglect is a serious risk factor for falls and is an impediment to the improvement of FIM-motor scores and favorable outcomes in terms of discharge destination and length of stay.^{31–34} Furthermore, for cognitive items, the degree of independence was low for problem-solving and memory in the MMCM. Although the current study did not investigate factors associated with ADL improvement, it is nonetheless important to carefully increase independence through training and environmental settings that address higher brain dysfunction, such as unilateral spatial neglect. Characteristically, the findings for bladder and bowel control were mixed in the MMCM (independence and complete dependence). Although the MCCM responded to items related to bladder and bowel control with complete dependence, the MMCI responses were close to independence. This suggests that MMCM represents the boundary between independence and dependence for bladder and bowel control, and an intensive intervention approach may be effective in this class. In this study, the median FIM-motor score was 62 in the MMCI and 48 in the MMCM. A previous study reported that more than 50% of patients with FIM-motor scores of 40–50 had bladder and bowel control scores of 5 or greater.⁸ This is consistent with the results of the present study. In the MCCMa group, the proportion of discharge to home

exceeded 80%, and the median length of stay was 90 days. A treatment regimen aimed at home discharge and a short length of stay is recommended for the MCCMa group.

MMCI responded to most of the motor items with “Modified Dependence” and to most of the cognitive items with “Independence.” MMCI showed some independence in grooming, dressing, toileting, transfer, and walking or wheelchair use, whereas MICM could perform many of these tasks independently. Therefore, with MMCI representing the boundary of independence for these items, we suggest that an intensive intervention approach for these items may be effective for patients with an ADL status of MMCI. In the MMCIa group, the proportion of patients discharged to home exceeded 90%, and the median length of stay was 65 days. Considering this length of stay for patients in this group, we recommend a treatment regimen aimed at home discharge.

MICM responded to most motor items with “Independence” and to most cognitive items with “Modified Dependence.” Although the cause of decreased independence for cognitive items was not examined in this study, stroke presents with dysfunction in various higher-order processes in the brain, such as unilateral spatial neglect and aphasia. The decreased expression and comprehension abilities in the MICM may be related to aphasia. In the MICMa group, the proportion of patients discharged to home exceeded 95%, and the median length of stay was 44 days. Previous studies have shown that aphasia is a major factor for extended length of stay in rehabilitation hospitals,³⁵ which is consistent with longer length of stay in the MICMa group than in the MICIa group. For patients with higher brain dysfunction, such as those with aphasia, an appropriate length of stay should be established, and appropriate training and adjustment should be provided to facilitate home discharge.

MICI responded to most motor and cognitive items with “Independence”; however, “Modified Dependence” was noted for difficult activities such as bathing, transfer to tub/shower, and climbing stairs. As a result, MICI was considered to represent basic ADL independence. In the MICIa group, the proportion of patients discharged to home exceeded 98%, and the median length of stay was 29 days. This suggests that a treatment approach for these patients should aim for early discharge and incorporate higher goals, including advanced movements that are not evaluated in the FIM.

Study Limitations and Future Directions

In the analysis of FIM data, most studies consider the seven-level FIM response for each component of the test.^{7,36} However, based on the purpose and the limitations of analy-

sis in the current study, we considered a three-level FIM to be suitable. Further consideration will be needed to yield any findings regarding analysis using the seven-level FIM or the categories verified for level integration.

In our analysis, missing data may not have been missing at random. However, because the percentage of missing data was small (2%), it was not considered to have a significant effect on the results. In this study, our analysis aimed to capture FIM response patterns to reflect ADL status in all clinical situations at different time points, although the number of time points differed in each case. Given that this study aimed to classify ADL status rather than to stratify individual patients, the multiple FIM records for each patient were regarded as independent and identically distributed, representing different ADL states at different time points. In addition, when comparing the length of stay among patient subgroups classified based on the class to which they belonged at admission, our preliminary analysis using only FIM records at the time of admission did not disagree with our conclusion. Furthermore, the length of stay examined in this study was based on the stay in the convalescent hospital and did not consider the length of stay in acute care hospitals. However, we chose to focus on convalescent hospitals to improve treatment regimens in this setting. We considered that more severely affected patients with poor ADL status would require a longer stay in an acute care setting. This means that an analysis of length of stay in an acute care hospital may show significant differences in patients subdivided according to ADL status at admission. However, the length of stay in an acute care hospital may not be entirely based on the severity of symptoms, highlighting the need for similar studies to consider the effects of the length of stay in this setting. Finally, this study was performed at a single center in Kanagawa; therefore, the data used in this study may be different from those obtained from other regions in Japan and/or the world. Conversely, in a data-driven society, it is crucial to assume that treatment results will vary depending on the treatment environment and region. Ultimately, it is critical to develop a general analytical method and system that can propose clinical treatment options based on easily accessible data at each facility.

CONCLUSIONS

The current study demonstrated that LCA could be used to clarify ADL structure in patients with stroke. LCA identified six latent classes of ADL status based on the pattern of responses to FIM items on an ordinal scale, incorporating

both motor and cognitive items. Furthermore, this analysis revealed that the length of stay and discharge destination differed depending on ADL status at admission. These findings highlight the importance of clarifying the structure of ADL status when designing an appropriate treatment regimen.

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CONFLICTS OF INTEREST

The authors report no conflicts of interest.

REFERENCES

1. Dam M, Tonin P, Casson S, Ermani M, Pizzolato G, Iaia V, Battistin L: The effects of long-term rehabilitation therapy on poststroke hemiplegic patients. *Stroke* 1993;24:1186–1191. DOI:10.1161/01.STR.24.8.1186, PMID:8342195
2. Meyer MJ, Pereira S, McClure A, Teasell R, Thind A, Koval J, Richardson M, Speechley M: A systematic review of studies reporting multivariable models to predict functional outcomes after post-stroke inpatient rehabilitation. *Disabil Rehabil* 2015;37:1316–1323. DOI:10.3109/09638288.2014.963706, PMID:25250807
3. Brown AW, Lee M, Lennon RJ, Niewczyk PM: Functional performance and discharge setting predict outcomes 3 months after rehabilitation hospitalization for stroke. *J Stroke Cerebrovasc Dis* 2020;29:104746. DOI:10.1016/j.jstrokecerebrovasdis.2020.104746, PMID:32151479
4. Yang DG, Gu R, Sato S, Zheng F, Sano M, Yashima C, Eguchi J, Ishida T, Kawaguchi M, Kubo J, Kakuda W: The Ability for Basic Movement Scale II can predict functional outcome and discharge destination in stroke patients. *J Stroke Cerebrovasc Dis* 2020;29:104484. DOI:10.1016/j.jstrokecerebrovasdis.2019.104484, PMID:31753717
5. Kosorok MR, Laber EB: Precision medicine. *Annu Rev Stat Appl* 2019;6:263–286. DOI:10.1146/annurev-statistics-030718-105251, PMID:31073534

6. Linacre JM, Heinemann AW, Wright BD, Granger CV, Hamilton BB: The structure and stability of the functional independence measure. *Arch Phys Med Rehabil* 1994;75:127–132. DOI:10.1016/0003-9993(94)90384-0, PMID:8311667
7. Tsuji T, Sonoda S, Domen K, Saitoh E, Liu M, Chino N: ADL structure for stroke patients in Japan based on the functional independence measure. *Am J Phys Med Rehabil* 1995;74:432–438. DOI:10.1097/00002060-199511000-00007, PMID:8534387
8. Koyama T, Matsumoto K, Okuno T, Domen K: Relationships between independence level of single motor-FIM items and FIM-motor scores in patients with hemiplegia after stroke: an ordinal logistic modelling study. *J Rehabil Med* 2006;38:280–286. DOI:10.1080/16501970600731420, PMID:16931457
9. Tokunaga M, Tori K, Eguchi H, Kado Y, Ikejima Y, Ushijima M, Miyabe S, Tsujimoto S, Fukuda E: The stratification of motor FIM and cognitive FIM and the creation of four prediction formulas to enable higher prediction accuracy of multiple linear regression analysis with motor FIM gain as the objective variable—an analysis of the Japan Rehabilitation Database. *Jpn J Compr Rehabil Sci* 2017;8:21–29.
10. Wraith D, Wolfe R: Classifying patients by their characteristics and clinical presentations; the use of latent class analysis. *Respirology* 2014;19:1138–1148. DOI:10.1111/resp.12408, PMID:25302757
11. McCutcheon AL: Latent class analysis. In: Niemi RG, editor. *Quantitative applications in the social sciences*. Newbury Park, CA: Sage; 1987. pp. 4–37.
12. Kongsted A, Nielsen AM: Latent class analysis in health research. *J Physiother* 2017;63:55–58. DOI:10.1016/j.jphys.2016.05.018, PMID:27914733
13. Thomas E, Barrett JH, Donn RP, Thomson W, Southwood TR, British Paediatric Rheumatology Group: Subtyping of juvenile idiopathic arthritis using latent class analysis. *Arthritis Rheum* 2000;43:1496–1503. DOI:10.1002/1529-0131(200007)43:7<1496::AID-ANR12>3.0.CO;2-C, PMID:10902751
14. Greig F, Hyman S, Wallach E, Hildebrandt T, Rapaport R: Which obese youth are at increased risk for type 2 diabetes? Latent class analysis and comparison with diabetic youth. *Pediatr Diabetes* 2012;13:181–188. DOI:10.1111/j.1399-5448.2011.00792.x, PMID:22050535
15. Garipey G, Malla A, Wang J, Messier L, Strychar I, Lesage A, Schmitz N: Types of smokers in a community sample of individuals with type 2 diabetes: a latent class analysis. *Diabet Med* 2012;29:586–592. DOI:10.1111/j.1464-5491.2011.03493.x, PMID:22004370
16. Benchimol EI, Smeeth L, Guttman A, Harron K, Moher D, Petersen I, Sørensen HT, von Elm E, Langan SM, RECORD Working Committee: The REporting of studies Conducted using Observational Routinely collected health Data (RECORD) statement. *PLoS Med* 2015;12:e1001885. DOI:10.1371/journal.pmed.1001885, PMID:26440803
17. Center for Functional Assessment Research and the Uniform Data System for Medical Rehabilitation. In: *Guide for use of the uniform data set for medical rehabilitation including the Functional Independence Measure (FIM), Version 3.0*. Buffalo, NY: State University of New York; 1990.
18. Dodds TA, Martin DP, Stolov WC, Deyo RA: A validation of the Functional Independence Measurement and its performance among rehabilitation inpatients. *Arch Phys Med Rehabil* 1993;74:531–536. DOI:10.1016/0003-9993(93)90119-U, PMID:8489365
19. Chumney D, Nollinger K, Shesko K, Skop K, Spencer M, Newton RA: Ability of Functional Independence Measure to accurately predict functional outcome of stroke-specific population: systematic review. *J Rehabil Res Dev* 2010;47:17–29. DOI:10.1682/JRRD.2009.08.0140, PMID:20437324
20. Thorpe ER, Garrett KB, Smith AM, Reneker JC, Phillips RS: Outcome measure scores predict discharge destination in patients with acute and subacute stroke: a systematic review and series of meta-analyses. *J Neurol Phys Ther* 2018;42:2–11. DOI:10.1097/NPT.0000000000000211, PMID:29232307
21. Weller BE, Bowen NK, Faubert SJ: Latent class analysis: a guide to best practice. *J Black Psychol* 2020;46:287–311. DOI:10.1177/0095798420930932
22. Hachisuka K, Okazaki T, Ogata H: Self-rating Barthel index compatible with the original Barthel index and the Functional Independence Measure motor score. *J UOEH* 1997;19:107–121. DOI:10.7888/juoeh.19.107, PMID:9194213
23. Vermunt JK, Magidson J: *Technical guide for latent GOLD 5.1: basic, advanced, and syntax*. Belmont, MA: Statistical Innovations Inc. 2016. <http://www.statistica-innovations.com> Accessed 14 July 2021.

24. Schreiber JB: Latent class analysis: an example for reporting results. *Res Social Adm Pharm* 2017;13:1196–1201. DOI:10.1016/j.sapharm.2016.11.011, PMID:27955976
25. Nylund-Gibson K, Choi AY: Ten frequently asked questions about latent class analysis. *Transl Issues Psychol Sci* 2018;4:440–461. DOI:10.1037/tps0000176
26. Dickson HG, Köhler F: The multi-dimensionality of the FIM motor items precludes an interval scaling using Rasch analysis. *Scand J Rehabil Med* 1996;28:159–162. PMID:8885038
27. Chevalley O, Truijien S, Saeys W, Opsommer E: Socio-environmental predictive factors for discharge destination after inpatient rehabilitation in patients with stroke: a systematic review and meta-analysis. *Disabil Rehabil* 2021;18:1–12. DOI:10.1080/09638288.2021.1923838, PMID:34004119
28. Koyama T, Sako Y, Konta M, Domen K: Poststroke discharge destination: functional independence and sociodemographic factors in urban Japan. *J Stroke Cerebrovasc Dis* 2011;20:202–207. DOI:10.1016/j.jstrokecerebrovasdis.2009.11.020, PMID:20621511
29. Tokisato K, Tokunaga M, Okumura K, Miyamoto U, Katsura K, Watanabe S, Nakanishi R, Yamana H: A survey of the stroke patients transferred to acute hospitals or died with complications in a convalescent rehabilitation ward [in Japanese]. *J Clin Rehabil* 2015;24:734–739.
30. Stineman MG, Ross R, Maislin G, Fiedler RC, Granger CV: Risks of acute hospital transfer and mortality during stroke rehabilitation. *Arch Phys Med Rehabil* 2003;84:712–718. DOI:10.1016/S0003-9993(03)04850-5, PMID:12736887
31. Czernuszenko A, Członkowska A: Risk factors for falls in stroke patients during inpatient rehabilitation. *Clin Rehabil* 2009;23:176–188. DOI:10.1177/0269215508098894, PMID:19164405
32. Chen P, Hreha K, Kong Y, Barrett AM: Impact of spatial neglect on stroke rehabilitation: evidence from the setting of an inpatient rehabilitation facility. *Arch Phys Med Rehabil* 2015;96:1458–1466. DOI:10.1016/j.apmr.2015.03.019, PMID:25862254
33. Tsujimoto K, Mizuno K, Kobayashi Y, Tanuma A, Liu M: Right as well as left unilateral spatial neglect influences rehabilitation outcomes and its recovery is important for determining discharge destination in subacute stroke patients. *Eur J Phys Rehabil Med* 2020;56:5–13. DOI:10.23736/S1973-9087.19.05595-3, PMID:31134787
34. Yoshida T, Mizuno K, Miyamoto A, Kondo K, Liu M: Influence of right versus left unilateral spatial neglect on the functional recovery after rehabilitation in sub-acute stroke patients. *Neuropsychol Rehabil* 2020;23:1–22. DOI:10.1080/09602011.2020.1798255, PMID:32703088
35. Wee JY, Hopman WM: Stroke impairment predictors of discharge function, length of stay, and discharge destination in stroke rehabilitation. *Am J Phys Med Rehabil* 2005;84:604–612. DOI:10.1097/01.phm.0000171005.08744.ab, PMID:16034230
36. Heinemann AW, Linacre JM, Wright BD, Hamilton BB, Granger C: Relationships between impairment and physical disability as measured by the Functional Independence Measure. *Arch Phys Med Rehabil* 1993;74:566–573. DOI:10.1016/0003-9993(93)90153-2, PMID:8503745