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Does scoring patient complexity using COMPRI predict the length of hospital stay? A multicentre case–control study in Japan

Daiki Yokokawa ,[1] Kiyoshi Shikino ,[1] Yasuhiro Kishi,[2] Toshiaki Ban,[3] Shigeyoshi Miyahara,[4] Yoshiyuki Ohira,[1,5] Yasutaka Yanagita,[1] Yosuke Yamauchi,[1] Yasushi Hayashi,[1] Kosuke Ishizuka,[1,6] Yuta Hirose,[1,4] Tomoko Tsukamoto,[1] Kazutaka Noda,[1] Takanori Uehara,[1] Masatomi Ikusaka[1]

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For numbered affiliations see end of article.

Correspondence to
Dr Daiki Yokokawa;
dyokokawa6@gmail.com

ABSTRACT

Objective To clarify the factors associated with prolonged hospital stays, focusing on the COMplexity PRediction Instrument (COMPRI) score's accuracy in predicting the length of stay of newly hospitalised patients in general internal medicine wards.

Design A case–control study.

Setting Three general internal medicine wards in Chiba Prefecture, Japan.

Participants Thirty-four newly hospitalised patients were recruited between November 2017 and December 2019, with a final analytic sample of 33 patients. We included hospitals in different cities with general medicine outpatient and ward facilities, who agreed to participate. We excluded any patients who were re-hospitalised within 2 weeks of a prior discharge.

Primary and secondary outcome measures Patients' COMPRI scores and their consequent lengths of hospital stay.

Results The 17 patients (52%) allocated to the long-term hospitalisation group (those hospitalised ≥14 days) had a significantly higher average age, COMPRI score and percentage of participants with comorbid chronic illnesses than the short-term hospitalisation group (<14 days). A logistic regression model (model A, comprising only the COMPRI score as the explanatory variable) and a multiple logistic regression model (model B, comprising variables other than the COMPRI score as explanatory variables) were created as prediction models for the long-term hospitalisation group. When age ≥75 years, a COMPRI score ≥6 and a physician with 10 years' experience were set as explanatory variables, model A showed better predictive accuracy compared with model B (fivefold cross-validation, area under curve of 0.87 vs 0.78). The OR of a patient with a COMPRI score of ≥6 joining the long-term hospitalisation group was 4.25 (95% CI=1.43 to 12.63).

Conclusions Clinicians can use the COMPRI score when screening for complexity assessment to identify hospitalised patients at high risk of prolonged hospitalisation. Providing such patients with multifaceted and intensive care may shorten hospital stays.

Strengths and limitations of this study

- We examined the usefulness of the COMplexity PRediction Instrument (COMPRI) score in predicting prolonged length of stay (LOS) among patients in general internal medicine wards.
- We compared the COMPRI score and a model combining age, sex and medical history to see which was better for predicting LOS.
- This study was a multicentre collaborative study in Japan.
- The primary disease at the time of hospitalisation was not recorded.
- Only six physicians conducted the COMPRI assessments, and nurses' experience was not measured.

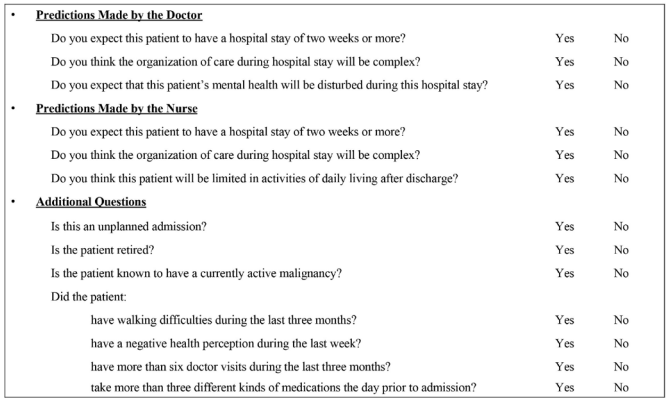
INTRODUCTION

Prolonged hospital stays have several negative consequences, including increased medical expenses. This issue is particularly prevalent in Japan; in 2017, the average length of stay (LOS) in Japanese hospitals was 30.6 days.[1] This represents a decrease from the 1990 number of 47.4 days[1]; however, this duration remains longer than that reported for all other Organisation for Economic Co-operation and Development Countries, with the exception of South Korea.[2] Although several scales have been proposed for predicting LOS, there is currently no standard scale in this regard. The Simple Clinical Score (SCS) tool,[3] which was designed for prognosis prediction in general internal medicine wards, is a clinical index that centres on objective indicators such as age and vital signs and is capable of predicting LOS. However, it has been reported that the SCS is not suitable for predicting LOS durations of longer than 72 hours in newly hospitalised patients in general internal medicine wards; moreover,

the SCS has been reported as inferior to assessments made by clinical physicians.[4] Another tool is the PRO-AGE scoring system, a predictive model for the hospitalisation and long-term stay of older patients admitted from emergency departments.[5] As an example, when used in scoring men who are ≥90 years old, had been hospitalised in the previous 6 months, had experienced weight loss of ≥5% in the previous year and who showed acute mental alteration, acute functional decline and fatigue, this system predicted hospitalisation of 7 days or more, with a receiver operating characteristic area under the curve (ROC-AUC) of 0.79. The results of the PRO-AGE scoring system were superior to that of the Identification of Seniors at Risk (ISAR) tool, which was developed to predict adverse health outcomes—including death—after emergency department visits, during the 6 months after the emergency department visit.[6] Another related tool is the FRAIL scale, which was studied as a predictor of potentially unfavourable outcomes among older adults, particularly in the surgical context.[7] However, the study was conducted in the geriatric emergency department of a private tertiary hospital in São Paulo, Brazil; therefore, its generalisability is limited when applied to various socioeconomic and cultural groups.

A previous study, in which a tool that could accurately predict LOSs of <72 hours was developed, indicated that concomitant use of more than five drugs, being older than 80 years, the presence of cognitive dysfunction or confusion and unplanned hospitalisations in the preceding 4 weeks are essential variables to consider when predicting LOS.[8] However, it should be noted that, for these findings, the ROC-AUC was only 0.68.[8] Other studies have indicated that advanced age,[1] testing schedule adjustments,[9] delayed decision-making by physicians,[9] unavailability of post-discharge facilities,[9] co-existence of physical illnesses[10] and co-existence of psychiatric illnesses[11] contribute to prolonged hospital stays. Further, illness type has also been found to influence LOS in Japan, with the average stays for mental and behavioural disorders, nervous system disorders and circulatory system disorders being notably long.[1] Moreover, multimorbidity, which has become an issue among older adults, is thought to predict unplanned hospitalisations and prolonged hospital stays.[12 13] Notably, the above-mentioned factors that prolong LOS can be summarised as representing the concept of patient complexity and vulnerability. Vulnerability is determined as a combination of the patient's physical and social characteristics, exposure to shocks that affect well-being and their ability to cope with those shocks.[14] Complexity is expressed in terms of socioeconomics, culture, environment/ecology, and behaviour, in addition to biology/genetics.[15]

Assessing patient complexity at the time of hospital admission is recommended, as this can help ensure that the required medical resources are efficiently distributed.[16] INTERMED[17 18] was developed to assess patient complexity and necessity of care and has been found to be capable of determining LOS.[18 19] However,



- **Predictions Made by the Doctor**
  - Do you expect this patient to have a hospital stay of two weeks or more? Yes No
  - Do you think the organization of care during hospital stay will be complex? Yes No
  - Do you expect that this patient's mental health will be disturbed during this hospital stay? Yes No
- **Predictions Made by the Nurse**
  - Do you expect this patient to have a hospital stay of two weeks or more? Yes No
  - Do you think the organization of care during hospital stay will be complex? Yes No
  - Do you think this patient will be limited in activities of daily living after discharge? Yes No
- **Additional Questions**
  - Is this an unplanned admission? Yes No
  - Is the patient retired? Yes No
  - Is the patient known to have a currently active malignancy? Yes No
  - Did the patient:
    - have walking difficulties during the last three months? Yes No
    - have a negative health perception during the last week? Yes No
    - have more than six doctor visits during the last three months? Yes No
    - take more than three different kinds of medications the day prior to admission? Yes No

Figure 1 COMplexity PRediction Instrument (COMPRI).

trained evaluators are needed to perform INTERMED measurements, and the assessment time is relatively long, at approximately 20 min.[20] To address these shortcomings, the European Union Group developed the COMplexity PRediction Instrument (COMPRI), based on data from 11 wards in Europe. COMPRI is an indicator that can predict LOS and patient complexity.[21–23] COMPRI assessments (figure 1) can be performed in 5 min and can be used to screen high-complexity patients. Assessments are made by awarding points based on the patient's complexity, with higher scores indicating higher complexity. The assessments are performed by a physician (3 points), a nurse (3 points) and through consideration of the patient's medical history (7 points); thus, the maximum is 13 points. A Netherlands-based study[19] on patients in general internal medicine wards showed that groups with high COMPRI scores (more than 6 points) had longer LOS than did those with low COMPRI scores (23.7 vs 10.9 days). It was also found that COMPRI could be used to identify patients who would require more than 8 days of hospitalisation (ROC-AUC: 0.73). However, despite this observed effectiveness of COMPRI, it is necessary to carefully examine whether this scoring system, which was developed in Europe, is applicable in Japan, given the differences in cultures and medical systems. For example, the average LOS in the Netherlands was 5.5 days in 2017[2]; much shorter than in Japan. Despite this potential of COMPRI, there have been few Japan-based studies on the relationship between COMPRI scores and LOS in Japanese hospitals. A previous single-centre study that examined patients in a tertiary care hospital reported that a COMPRI score of over 6 predicts an LOS of more than 30 days (with a sensitivity of 94.4% and a specificity of 60.8%).[20] Therefore, one of the aims of the present study was to recreate the results of this previous study through a multicentre study. More specifically, one objective was to investigate and analyse factors related to prolonged LOS, including COMPRI score, in patients who were newly hospitalised in general internal medicine wards. Another objective was to compare two models (a model based on the COMPRI score and a model based on age, sex, co-existence of physical illnesses, co-existence

of psychiatric illness and physician experience) regarding their respective abilities to predict prolonged LOS.

MATERIALS AND METHODS

Design

This research represents a case–control study and was implemented in accordance with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Participants

From November 2017 to December 2019, we recruited newly hospitalised patients from three general internal medicine wards in Chiba Prefecture, Japan. We included hospitals in different cities that have general medicine outpatient and ward facilities and that agreed to participate in the study. There were no age criteria for participants. We excluded any patients who were being re-hospitalised after being discharged less than 2 weeks previously. Participants with missing data were also excluded.

COMPRI scores

The patients' COMPRI scores (figure 1) were measured at the time of their hospital admission. COMPRI score measurements require subjective assessment by both a physician and a nurse. In this study, when physicians determined that a patient required hospitalisation, they input this information on the form, and the nurses who were in charge of outpatients then provided scores for the patient. Patients, or their family members, were also interviewed at the time of admission to obtain further details regarding the patients' medical history. The Japanese adaptation of the COMPRI score is based on research conducted by Kishi *et al*[20]

Other factors

For each patient, age, sex, co-existence of physical illnesses, co-existence of psychiatric illnesses, the responding physician's years of experience (hereafter, 'physician experience') and whether the hospitalisation site was a tertiary care hospital were recorded. The physical illnesses considered included chronic lung disease, diabetes, heart disease, hypertension, rheumatic disease, neurological disorders, malignant tumours and disabilities.[10] Meanwhile, the psychiatric illnesses considered included delirium, dementia, depression, anxiety disorders, schizophrenia, drug/alcohol use disorders and other psychiatric illnesses. LOS was defined as the number of days from the date of admission to either the date of discharge or transfer; for patients who died, their date of death was considered to represent their date of discharge.

Statistical analysis

The primary outcome was LOS. Generally, LOS varies depending on the primary disease and, as a result, there is no clear standard, even in Japan, regarding the cut-off point for prolonged LOS. However, multiple studies have set an LOS of more than 14 days as a cut-off.[24–28] Our study also followed this standard and allocated patients with an LOS of 14 days or more to a 'long-term hospitalisation group' and patients with an LOS of fewer than 14 days to a 'short-term hospitalisation group'. We then compared the two groups in regard to COMPRI score, age and physician experience (using the Mann-Whitney U test), sex, co-existence of physical illnesses and co-existence of psychiatric illnesses (using χ^2 test/Fisher's exact test).

Sample size estimates were conducted with reference to previous studies.[19] To perform the Mann-Whitney U test for the primary outcome of LOS, the CI was set at 95%, the detectability at 0.8, the median COMPRI score of the long-term hospitalisation group at 9.5, the median score value of the short-term hospitalisation group at 6.0 and the SD at 4.0. Meanwhile, a target sample size of 24 patients was assumed.

Next, two prediction models were designed. Model A was a logistic regression model based only on the COMPRI score, and model B was a multiple logistic regression model that featured age, sex, co-existence of physical illnesses, co-existence of mental illnesses and physician experience as explanatory variables. These prediction models were used to conduct an ROC-AUC accuracy comparison based on stratified K-fold cross-validation. When identifying the constituent patients for the two groups, cut-offs for each variable were determined based on the ROC analyses, and these were set as explanatory variables when creating the variables for model B. Age older than 75 years (which is a defining characteristic of the target patients of Japan's late-stage older adult healthcare system) was set as the explanatory variable.

All statistical analyses were conducted using Python (3.6.8) and scikit-learn (0.22.1), which is a module for machine learning in Python. For all analyses, the significance level was set at <5%.

Patient and public involvement

The patients and public had no direct involvement in this research.

RESULTS

Across the three facilities, a total of 34 patients (28 patients from hospital A, 1 from hospital B and 5 from hospital C) were recruited. Of these, one patient with missing values was excluded; thus, 33 patients were analysed. No participants were re-admitted within 2 weeks. The median LOS was 14 days (Q1–Q3: 6–28 days, T1–T3: 7.3–23.0 days). No participants died during the study period. The overall median age was 77 years (Q1–Q3: 65–86 years), and 14 patients were male (42%). Twenty-two patients had co-existing physical illnesses (67%), and 12 patients had co-existing psychiatric illnesses (36%). Seventeen patients were allocated to the long-term hospitalisation group (52%). Compared with the short-term hospitalisation group,

Table 1 Participant characteristics

	Total		Long-term hospitalisation group		Short-term hospitalisation group		P value
Cases (n, %)	33	(100)	17	(52)	16	(48)	
Age (median, Q1–Q3)	77	(65–86)	84	(75–88)	70	(51–81)	0.018*
Male (n, %)	14	(42)	9	(53)	5	(31)	0.36†
COMPRI (median, Q1–Q3)	7	(4–10)	10	(8–11)	4	(3–5)	<0.001*
Co-existent physical illness (n, %)	22	(67)	15	(88)	7	(44)	0.019†
Co-existent psychiatric illness (n, %)	12	(36)	9	(53)	3	(19)	0.093†
Physician experience (median, Q1–Q3)	9	(9–10)	9	(9–10)	9	(8–9)	0.44*
Hospitalisation in a tertiary care hospital (n, %)	5	(15)	1	(5.9)	4	(25)	0.17†

Long-term hospitalisation group: a length of stay of 14 days or longer; short-term hospitalisation group: a length of stay of less than 14 days.
*Mann-Whitney U test.
†χ^2 test.
COMPRI, COMplexity PRediction Instrument.

the long-term hospitalisation group had a significantly higher age (84 vs 70 years; p=0.018), COMPRI score (10 vs 4; p<0.001) and percentage of members with physical illnesses (15% vs 7%; p=0.019). The patients' characteristics are shown in table 1. Additionally, across the sample, the COMPRI assessments were conducted by six different physicians; however, there were no significant differences between the two groups in regard to physician experience. There were also no significant intergroup differences in the proportion of members hospitalised in tertiary care hospitals.

Table 2 and figure 2 show the results of a multiple logistic regression analysis where, based on the ROC analysis, a COMPRI score of 6 or higher and physician experience of 10 years or longer were set as cut-offs. Compared with model B, model A showed favourable prediction accuracy through fivefold cross-validation (AUC=0.87 (±0.06) and 0.78 (±0.12) for model A and model B, respectively; figure 2). The OR for a patient with a COMPRI score of ≥6 joining the long-term hospitalisation group was 4.25 (95% CI=1.43 to 12.63).

DISCUSSION

The COMPRI score, a method of easily assessing patient complexity, was significantly higher in the long-term hospitalisation group. This indicates that the COMPRI can better predict prolonged LOS when compared with models that combine age, sex and medical history.

There were several limitations to this study. First, the primary disease at the time of hospitalisation was not recorded. LOS is affected by the primary disease; in Japan, patients with psychiatric diseases and Alzheimer's disease have clearly longer LOSs when compared with patients with other diseases.[1] Nevertheless, our approach means our results can be applied regardless of the primary disease and can be used to comprehensively screen complexity in any type of patient. The second limitation concerns the possible existence of confounding factors. Several factors may prolong LOS (eg, unavailability of post-discharge facilities,[9] patient lifestyle and unavailability of care supporters[17]). Further, receiving interventions from social workers or from psychiatrists and liaison nurses can

Table 2 Results for the COMPRI model (model A) and the multivariate regression model (model B)

Dependent variable: LOS over 14 days (N=33)	Coefficients		95% CI for OR			
	B	SE	OR	Lower bound	Upper bound	P value
Model A						
COMPRI score of >6	1.45	0.56	4.25	1.43	12.63	0.009
Model B						
Aged over 75 years	0.23	0.76	1.26	0.28	5.61	0.766
Male	–0.05	0.73	0.95	0.23	4.00	0.948
Co-existent physical illness	0.33	0.72	1.39	0.34	5.70	0.649
Co-existent psychiatric illness	0.68	0.86	1.96	0.37	10.55	0.431
Physician possessing over 10 years of experience	0.05	0.80	1.05	0.22	5.01	0.952

COMPRI, COMplexity PRediction Instrument; LOS, length of stay.

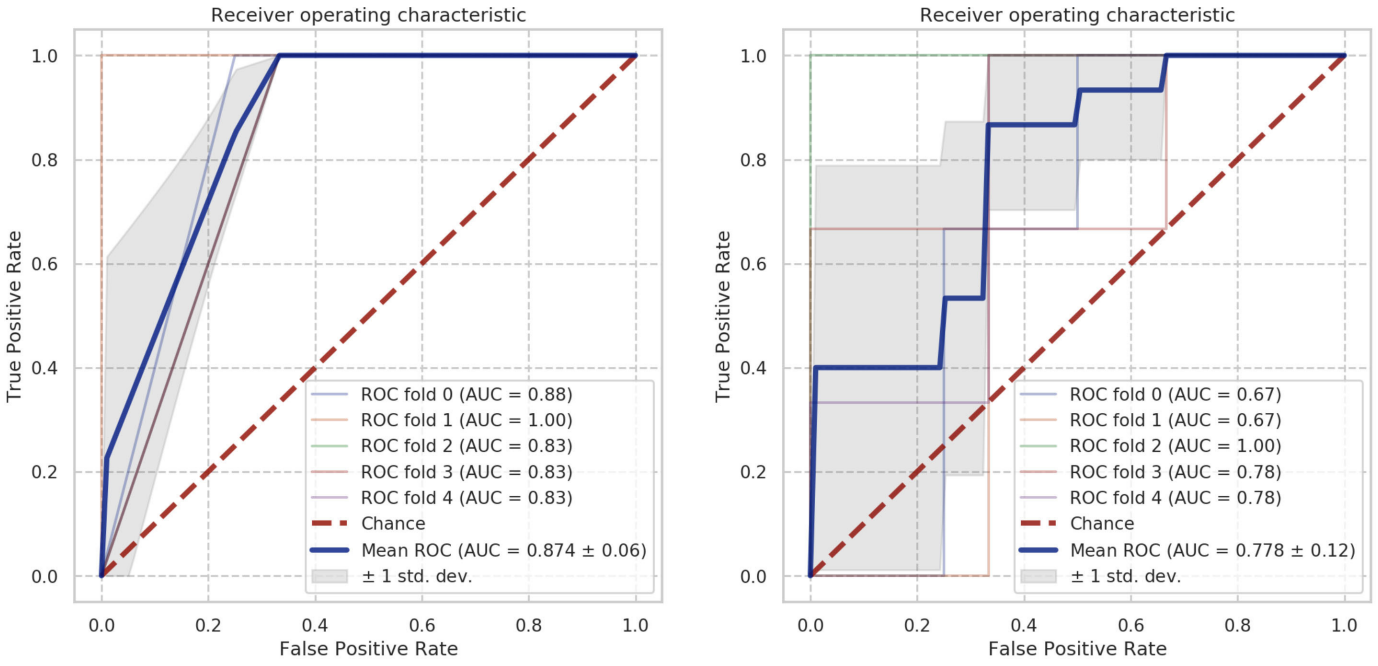


Figure 2 Receiver operating characteristic (ROC) analysis. AUC, area under the curve

also be confounding factors. Third, only six physicians conducted the COMPRI assessments, and the nurses' experience was not measured. The COMPRI scores may have been influenced by the medical staff's subjectivity. Subjective assessments generally depend on experience; thus, the assessing physician's experience may have influenced the prediction accuracy. There was no intergroup difference regarding physician experience; however, assessment values could vary between experienced and inexperienced physicians. There is no standard regarding the requisite experience to conduct COMPRI assessments, and no studies have reported that evaluator characteristics influence accuracy; thus, further investigations are needed. Fourth, there is a lack of comparison with other indicators used to predict length of hospital stay, such as the PRO-AGE scoring system, the ISAR tool and the FRAIL scale. Although these tools are simpler and quicker to implement than the COMPRI, the COMPRI has the advantage of assessing complexity by adding nurses' perspective to the assessment. Fifth, although the exclusion criteria for this study were based on those of a previous study,[19] there is no evidence in the previous literature regarding the exclusion of patients who had been re-admitted within 2 weeks. Sixth, this study took a lot of time due to insufficient inclusion of patients. This was because we were unable to inform eligible inpatients about the study or obtain their consent. Therefore, the number of patients included varied greatly among hospitals, and we were unable to conduct analyses for each individual hospital. If more patients had been enrolled, the differences between model A and model B may have become more apparent.

Previous studies have used various definitions of long-term hospitalisation. A Japan-based study of patients in tertiary care hospitals used ≥6 as the cut-off for the COMPRI score, and long-term hospitalisation was defined as an LOS of more than 30 days.[20] Further, in a Netherlands-based study of patients in a general internal medicine ward, ≥6 was again used as the cut-off; however, the LOS measured was 8 days or longer.[19] The present study used a cut-off of ≥6 points to predict an LOS of over 14 days in patients in general internal medicine wards. Patients were recruited from university hospitals, which are tertiary care hospitals and regional core hospitals, which provide secondary care. However, the short-term hospitalisation group featured more patients from tertiary care hospitals than did the long-term hospitalisation group. The findings mentioned above indicate that definitions of long-term hospitalisation vary widely, depending on factors such as the country, the scale of the medical institution, the hospitalised patients and the medical care system. This study was conducted in Japan, and the criteria for LOS set at 14 days may not be generalisable to other settings. However, the indicator of a COMPRI score of ≥6 may be generalisable to all settings because multiple studies with differing definitions of long-term hospitalisation have effectively used this cut-off value. Further, the present research results were obtained from multiple facilities in Japan, which may increase the external validity of performing LOS prediction based on this indicator.

In our study, the average age of the long-term hospitalisation group was significantly higher than that of the short-term hospitalisation group. COMPRI score and age are significantly correlated with LOS,[20] and it has been suggested that age influences complexity. The question, 'Is the patient retired?' may confound with age in the COMPRI score (figure 1). In Japan, illnesses associated with long LOS include mental and behavioural disorders, nervous system disorders and cardiovascular disease.[1]

These associations were identified through analysis of cases for which these diseases represented the primary condition; however, LOS may also be predicted to be prolonged when these diseases are the secondary condition. The co-existence of dementia is also a risk factor for prolonging LOS[29]; similarly, it is likely that the increased prevalence of Alzheimer's disease due to societal ageing will prolong LOS through multimorbidity. Notably, the relationship between chronic physical multimorbidity and depressive symptoms has been indicated in multiple studies.[30–33]

A high COMPRI score (ie, biological, psychological and social fragility) is a risk factor for the development of delirium.[34] In an ageing society, it is desirable to assess complexity (including physical and psychiatric illnesses) at the time of hospitalisation. Providing social support or early interventions for high-complexity patients through psychiatric liaisons should reduce LOS. Studies have shown that, in patients aged over 65 years with high COMPRI scores, LOS decreases when consultation liaison nurses conduct simple psychiatric interventions, introduce assistive services and provide post-discharge care.[35]

Comparisons between the two models regarding their respective abilities to predict long-term hospitalisation showed that the model that featured only the COMPRI score had higher accuracy. Referencing the COMPRI question items shows that the two models had overlapping sections regarding age and the co-existence of other illnesses. A possible reason for the difference in accuracy is that the COMPRI score included subjective assessments based on the physician's experience, which may have improved the accuracy. COMPRI combines subjective indicators of complexity with objective indicators to quickly and efficiently identify patients who require care.[21] This is notable because physicians often conduct assessments based on objective indicators, and in many cases these assessments do not correlate with nurses' assessments.[21] Differences between doctors and nurses in regard to assessments of complexity reflect differing perspectives on patient care; this should be considered when performing complexity assessments that feature multiple perspectives. Clinicians can use the COMPRI score to screen hospitalised patients for complexity assessment to identify patients at high risk for prolonged hospitalisation. Providing such patients with multifaceted and intensive care may lead to shorter hospital stays. Ultimately, we hope that simple methods such as the COMPRI score will be adopted by more healthcare organisations.

CONCLUSION

The results of this multicentre study suggest that a COMPRI score of ≥6 is useful for predicting LOS among patients in general internal medicine wards. The COMPRI score tends to predict prolonged LOS more accurately compared with only considering age, sex and co-existent illnesses. Future research questions include examining patient outcomes and costs—in other words, whether multifaceted care interventions for high-risk patients will shorten the length of care.

Author affiliations
[1]Department of General Medicine, Chiba University Hospital, Chiba, Japan
[2]Department of Psychiatry, Nippon Medical School Musashikosugi Hospital, Kawasaki, Japan
[3]Department of Internal Medicine, Isumi Medical Center, Isumi, Japan
[4]Department of Internal Medicine, Funabashi Futawa Byoin, Funabashi, Japan
[5]Department of General Medicine, International University of Health and Welfare, School of Medicine, Narita, Japan
[6]Department of General Medicine, Eastern Chiba Medical Center, Togane, Japan

Contributors DY, KS and YK were involved in the design of the study. DY, KS, TB, SM, YO, YYanagita, YYamauchi, YH, KI, TT, KN, TU and YH performed data collection. DY, TB, SM and YO, respectively, oversaw the data collection at each institution and obtained approval from the respective ethics review boards. DY and KS analysed the data. DY, KS and MI participated in the writing of the manuscript. All authors have read and approved the final manuscript. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. DY is responsible for the overall content as the guarantor.

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Competing interests All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The study protocol was approved by the Ethics Committee of Chiba University School of Medicine (Chiba, Japan; no 2731) and was approved by ethics committees at each of the three institutions. A detailed explanation of the study was given to all participants, who confirmed that they fully understood the information before voluntarily providing informed consent to participate. The trial was registered with the University Hospital Medical Information Network Clinical Trials Registry (unique trial number: UMIN000032715). Participants gave informed consent to participate in the study before taking part.

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ORCID iDs
Daiki Yokokawa http://orcid.org/0000-0003-0944-8664
Kiyoshi Shikino http://orcid.org/0000-0002-3721-3443

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