Association between comprehensive geriatric assessment and short-term outcomes among older adult patients with stroke: A nationwide retrospective cohort study using propensity score and instrumental variable methods

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ABSTRACT

Background: Comprehensive geriatric assessment (CGA) is a multidimensional and multidisciplinary method to identify geriatric conditions among older patients. The aim of the present study was to examine the associations between CGA and short-term outcomes among older adult inpatients with stroke.
Methods: The study was a nationwide, retrospective cohort study. We used the Diagnosis Procedure Combination database, a national Japanese inpatient database, to identify older adult stroke patients from 2014 to 2017. The associations between CGA and in-hospital mortality, length of hospital stay, readmission rate, rehabilitation intervention, and introduction of home health care were evaluated using propensity score matching and instrumental variable analysis.
Findings: We identified 338,720 patients, 21·3% of whom received CGA. A propensity score-matched analysis of 53,861 pairs showed that in-hospital mortality was significantly lower in the CGA group than in the non-CGA group (3·6% vs. 4·1%, $p < 0.001$). The rate of long-term hospitalization (> 60 days) was significantly lower in the CGA group than in the non-CGA group (8·7% vs. 10·1%, $p < 0.001$), and the rates of rehabilitation intervention (30·3% vs. 24·9%, $p < 0.001$) and home health care (8·3% vs. 7·6%, $p = 0.001$) were both higher in the CGA group than in the non-CGA group. Instrumental variable analysis showed similar results.
Interpretation: CGA was significantly associated with the examined short-term outcomes. These findings from Japan, one of the most aged countries worldwide, highlight the possible benefits of CGA for short-term outcomes and can be of use for health policy in other international contexts.
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1. Introduction

Older patients tend to suffer from multiple illnesses, disability, and poor mobility. Therefore, the goal of treatment should take individual needs into account. Comprehensive geriatric assessment (CGA) is a multidimensional, multidisciplinary method to identify geriatric conditions among older adults with frailty or disability [1].

Important components of CGA include scales to evaluate cognitive function, activities of daily living, depression, and vitality.

Previous studies have shown the favourable effects of CGA in an inpatient setting [2]. A meta-analysis demonstrated that CGA was associated with reduced mortality and improved physical function [3]. However, a systematic review showed that CGA increased the likelihood of living at home after discharge but did not reduce mortality [4]. These studies have been limited by small sample size, differences in reporting standards, and a lack of statistical adjustment

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Research in context

Evidence before this study

We conducted an extensive search of previous work on the effects of Comprehensive geriatric assessment (CGA) among older adult patients, including the PubMed (core clinical journals, from January 1969 to May 2019), Cochrane Library (from January 2001 to December 2019), and Japan Medical Abstracts Society (from January 2014 to May 2019) databases, with the search term 'comprehensive geriatric assessment'.

Some studies have revealed the benefits of CGA, including a reduction in mortality, whereas other studies have found no significant effects or inconsistent results. Moreover, we identified no previous studies that simultaneously investigated the effects of CGA on the rates of rehabilitation intervention and/or home health care.

Added value of this study

Our study answers the important questions of whether CGA is associated with mortality, length of stay, and related outcomes for older adult inpatients, using a nationwide database in Japan. To our knowledge, this is the first large-scale study (338,720 cases and 53,861 propensity-matched pairs) of CGA on stroke patients with a robust design and strong statistical analyses that clearly shows the association of CGA with rehabilitation intervention and home health care. The current study provides high-certainty evidence and demonstrates with an exceptional level of significance that CGA has favourable effects on short-term outcomes.

Implications of all the available evidence

The number of older adult patients has been growing rapidly, and providing these patients with effective made-to-order treatment and care with coordinated follow-up plans is becoming increasingly important. Our findings strongly suggest that CGA can play a very important role for assessments of these older adults and for their short-term outcomes. This finding for Japan, one of the most aged countries globally, will be of great use for health policy around the world.

for patient background. Therefore, the effect of CGA remains to be elucidated.

Stroke is one of the most common causes of mortality and disability, worldwide [5]. Stroke patients suffer from multiple disabilities such as hemiplegia and higher brain function deficits, and early screening for rehabilitation potential and early initiation of rehabilitation are recommended [2,6,7]. Medical, psychological, and functional capabilities are carefully evaluated through CGA. The results of these assessments can be promptly shared among all medical staff members and can be used to develop integrated plans for treatment and rehabilitation. Therefore, CGA is expected to play an important role in the assessment and management of older patients with stroke [2].

In this study, we aimed to examine the associations between CGA and mortality, length of hospital stay, and related outcomes among older stroke patients by comparing those who received CGA and those who did not. We used a national inpatient database in Japan to compare short-term outcomes between a CGA group and a non-CGA group.

2. Methods

2.1. Setting and participants

We used the Japanese Diagnosis Procedure Combination (DPC) database, which has been described in detail in previous studies

[8–12]. In short, the DPC is a case-mix patient classification and payment system for acute-care hospitals in Japan. All 82 university hospitals in Japan are obliged to adopt the DPC system, whereas use of the system is voluntary for community hospitals [10]. The DPC database includes administrative claims data and discharge abstract data from participating DPC hospitals. A total of 1189 of all 1585 DPC hospitals (75%) have participated in the DPC database as of 2014. The database includes the following information: a hospital identifier; patient's age and sex; main diagnosis, comorbidities at admission and complications after admission recorded using the International Classification of Diseases, 10th Revision (ICD-10) codes and text data in Japanese; medical procedures; medicines and devices used; fees for specified services; length of hospital stay; and discharge status.

Several types of information describing patients' conditions are also available in the database, including the Japan Coma Scale (JCS), the modified Rankin Scale (mRS), date of stroke onset, the Barthel Index (BI), daily life independence level, and plan for home health care after discharge. The JCS is a single-axis coma scale used in Japan. The mRS is a measure of disability or dependence in daily activities among people who have suffered a stroke or other causes of neurological disability, with values ranging from 0 (no symptoms) to 6 (death). The BI is a tool used to measure functional independence and mobility and to assess the need for assistance. The BI includes components such as feeding, bathing, grooming, and dressing, and points are summed across items. The daily life independence level describes whether a patient has dementia and the need for care (0: non-dementia; 1: dementia and needs observation; 2: dementia and needs care).

We also used the Reporting System for Functions of Medical Institutions, which is a census survey conducted yearly by the Ministry of Health, Labour and Welfare of Japan. This survey includes detailed structural information about institutions: location, hospital DPC category, number of hospital beds, number of nurses and physical therapists, emergency medical service system, and regional medical care support. We obtained the 2014 survey data and combined these data with the DPC database using the hospital identifier. This study followed the STROBE statement and its study approval was obtained from the Institutional Review Board of The University of Tokyo. Because of the anonymous nature of the data, the need for informed consent was waived.

This study used the DPC data from April 1, 2014, to March 31, 2017. We selected patients aged 65 or older who were admitted for stroke (ICD-10 code: I63). For patients with multiple hospitalisations during the investigation period, we selected the first admission. We excluded cases whose data could not be linked with the hospital survey data and cases with missing data. CGA should be done as soon as possible, usually within 7 days of admission. Therefore, we excluded patients who died within 7 days of admission, regardless of CGA provision status.

2.2. Baseline characteristics and outcomes

The Ministry of Health, Labour and Welfare has incentivised the implementation of CGA by introducing a fee for performing CGA for older adult inpatients. The provision of CGA was determined by records of this fee in the claims data. The main outcomes of the study were all-cause 14- and 30-day in-hospital mortality, overall in-hospital mortality, and the length of hospital stay among patients who were discharged alive. The proportion of patients with long-term hospitalization (> 60 days) was also evaluated. Among patients discharged alive, we also examined the proportion of patients who were readmitted to the same hospital within 180 days of discharge, the length of time from discharge to readmission, the rate of rehabilitation intervention at discharge, and the provision of home health care after discharge.

Patients' baseline characteristics included age, sex, emergency admission, JCS score, mRS score, date of stroke onset ($\leq$ 3 days, 4−7 days, $\geq$ 8 days, or asymptomatic), comorbidities, BI score, daily life independence level, drugs administered (antiplatelets, anticoagulants, edaravone, hyperosmolar solutions, and thrombolytics), surgery (thrombectomy, endovascular surgery, percutaneous angioplasty, thrombolysis, percutaneous thrombus collection, and percutaneous stent placement), and admission into special care units (intensive care unit, high care unit, or stroke care unit).

We categorised JCS scores into four groups: 0 (alert), 1−3 (dizzy), 10−30 (somnolent), and 100−300 (coma) [13]. Comorbidities were assessed using ICD-10 codes and converted to Charlson comorbidity index values based on Quan's algorithm [14]. Multiple chronic conditions have previously been reported to be associated with high odds of mortality and readmission [14,15], and we categorised Charlson comorbidity index values into five groups: 0, 1, 2, 3, and $\geq$ 4. We categorised BI scores into six groups: $\leq$ 20 (bedridden), 21−40 (totally assisted/almost unable to perform task), 41−60 (partially assisted/attempts task but unsafe), 61−85 (moderate help required), 85−99 (minimal help required), and 100 (fully independent).

Hospital volume was defined as the average annual number of patients eligible for the current study and was categorised by tertiles. Other hospital characteristics included the number of acute-care beds and DPC type (1: university hospital, 2: advanced treatment hospital, 3: normal hospital).

2.3. Statistical analyses

First, we compared the backgrounds of all eligible patients between those who received CGA and those who did not. Then, we conducted one-to-one matching between patients with and without CGA using propensity scores [16,17]. Confounding by indication is a common challenge in observational research where predictors of treatment also have prognostic value for the outcome of interest. The propensity score approach is used in observational studies to account for confounders and reduce the effect of potential confounding by indication. To estimate the propensity score, we used a logistic regression model for CGA as a function of all patient background and hospital factors. The C-statistic was used to evaluate the discriminatory ability of the model. Using the estimated propensity scores, nearest-neighbor matching without replacement was conducted. The calliper was set at 0·2 times the standard deviation of the estimated propensity score. Standardised differences were used to compare characteristics between the two groups before and after matching [18], and > 10% was regarded as imbalanced. We compared the outcomes between those who received CGA and those who did not in the propensity score-matched groups. Using the discharge status in the database, we also identified patients who were discharged to home with a plan of continuing outpatient visits, and we evaluated the proportion receiving rehabilitation intervention among this group of patients.

A limitation of the propensity score method is that it cannot control for unmeasured confounders. Although we used numerous variables in estimating the propensity score, the possibility of unmeasured confounders remained. Therefore, the E-value was calculated using the relative risk of in-hospital mortality to assess the effect that an unmeasured confounder could potentially have on the results of the study [19]. To further account for the possible effects of unmeasured confounders and determine the robustness of our results, we performed an analysis using an instrumental variable [20]. On the basis of the proportion of patients receiving CGA in each prefecture, we classified prefectures into those with a higher proportion (24 prefectures) and those with a lower proportion (23 prefectures) and used this classification as an instrumental variable. A two-stage residual inclusion model was used to estimate the effect of CGA on the outcomes among all eligible patients [21]. In the first stage, we measured the association between CGA and the instrumental variable, adjusting for patient and hospital characteristics. The residual of the first model was then included as an additional covariate in the second-stage regression model, which evaluated the associations between CGA and the outcomes.

Categorical variables are presented as numbers and percentages, and continuous variables are presented as means and standard deviations (SDs) or medians and interquartile ranges. McNemar tests were used for categorical variables, and Wilcoxon signed-rank tests were used for continuous variables. Statistical significance was defined as $p < 0.05$. All statistical analyses were conducted with IBM SPSS, Version 25·0 (IBM SPSS, Armonk, NY, USA).

2.4. Role of the funding source

The funders had no role in the execution of this study or the interpretation of the results.

3. Results

3.1. Patients

Fig. 1 illustrates the patient selection process. From the DPC database, 338,720 stroke patients from 1340 hospitals were identified. Overall, 21·3% (72,016/338,720) of the patients received CGA. Among the identified patients, 91,840 patients were excluded because of unavailable hospital data or patient background information, and 5518 patients died within 7 days. There were 241,362 patients who met the inclusion criteria (53,861 patients with CGA and 187,501 patients without CGA). Propensity score matching yielded 53,861 pairs, and the C-statistic for the logistic regression was 0·608 (95% confidence interval [CI]: 0·606−0·611).

Table 1 shows the baseline characteristics of the unmatched CGA and non-CGA groups (n = 241,362) and of the propensity score-matched groups (n = 107,722). In the unmatched groups, patients were more likely to receive CGA if they were admitted to large hospitals, were admitted on an emergency basis, had one or more comorbidities, or required less assistance. When the patient was somnolent or in a coma, CGA was conducted less frequently. After the propensity score matching, the distributions of patient background variables were well balanced between the patients with and without CGA.

Table 2 shows findings for drug treatment, surgery, and units into which patients were transferred. Patients in the CGA group were more likely to have received antiplatelets, edaravone, and hyperosmotic solutions, compared with those in the non-CGA group. After propensity score matching, these baseline patient characteristics were also balanced between the groups. In total (n = 107,722), 74·6%, 66·1%, 62·5%, 10·0%, and 5·2% received antiplatelets, anticoagulants, edaravone, hyperosmotic solutions, and thrombolytics, respectively.

3.2. Outcomes

Overall in-hospital mortality was 6·3% (21,383/338,720), and the 7-, 14-, 30-day mortality values were 2·2% (7284/338,720), 3·0% (10,231/338,720), and 4·2% (14,314/338,720), respectively.

Table 3 shows the outcomes for the propensity score-matched patients in the CGA and non-CGA groups. In-hospital mortality was statistically significantly lower in the CGA group than in the non-CGA group (3·6% vs. 4·1%, $p < 0.001$), and the 14- and 30-day mortality values were also lower in the CGA group than in the non-CGA group (0·7% vs. 0·9%, $p < 0.001$ and 1·8% vs. 2·1%, $p < 0.001$, respectively).

The median length of hospital stay was the same in the two groups, with no significant difference in the distributions ($p > 0.999$). However, the percentage of long-term hospitalization (> 60 days) was statistically significantly lower in the CGA group than in the non-CGA group (8·7% vs. 10·1%, $p < 0.001$). The mean length of stay was
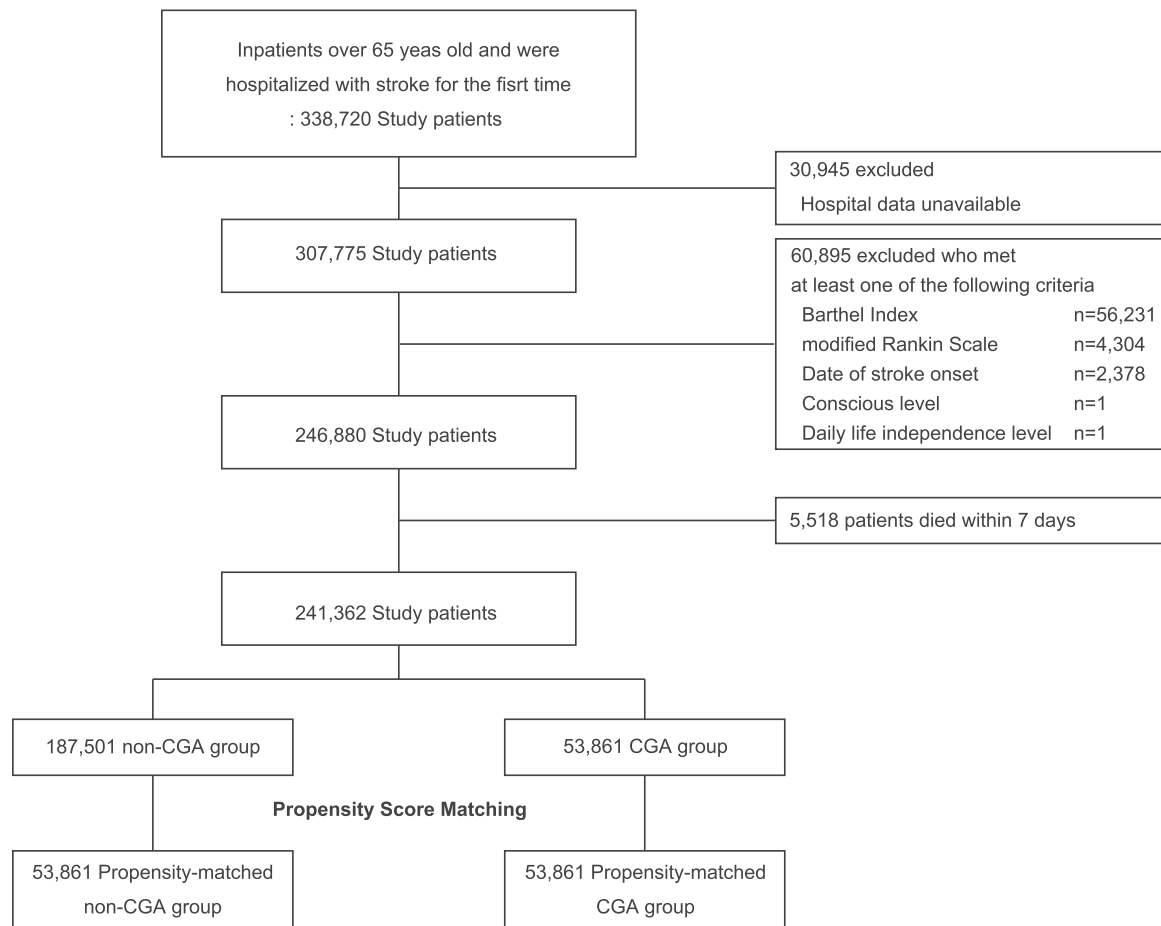
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┌─────────────────────────────────────────┐
│     Inpatients over 65 yeas old and were  │
│  hospitalized with stroke for the fisrt time │
│         : 338,720 Study patients          │
└─────────────────────────────────────────┘
                    │
                    │         ┌──────────────────────────────┐
                    │         │ 30,945 excluded               │
                    ├─────────│   Hospital data unavailable    │
                    │         └──────────────────────────────┘
          ┌──────────────────────┐
          │ 307,775 Study patients │
          └──────────────────────┘
                    │         ┌────────────────────────────────────────────┐
                    │         │ 60,895 excluded who met                      │
                    │         │ at least one of the following criteria        │
                    ├─────────│   Barthel Index              n=56,231        │
                    │         │   modified Rankin Scale      n=4,304         │
                    │         │   Date of stroke onset       n=2,378         │
                    │         │   Conscious level            n=1             │
                    │         │   Daily life independence level   n=1        │
          ┌──────────────────────┐└────────────────────────────────────────────┘
          │ 246,880 Study patients │
          └──────────────────────┘
                    │         ┌──────────────────────────────┐
                    ├─────────│ 5,518 patients died within 7 days │
                    │         └──────────────────────────────┘
          ┌──────────────────────┐
          │ 241,362 Study patients │
          └──────────────────────┘
                    │
         ┌──────────┴──────────┐
┌──────────────────┐   ┌──────────────────┐
│ 187,501 non-CGA  │   │ 53,861 CGA group  │
│      group       │   │                   │
└──────────────────┘   └──────────────────┘
         Propensity Score Matching
┌──────────────────┐   ┌──────────────────┐
│ 53,861 Propensity-│   │ 53,861 Propensity-│
│ matched           │   │ matched           │
│ non-CGA group     │   │ CGA group         │
└──────────────────┘   └──────────────────┘
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Fig. 1. Flow diagram of patient selection. (Legend) CGA: comprehensive geriatric assessment.

28·9 days (SD = 30·5 days) in the CGA group and 30·3 days (SD = 37·0 days) in the non-CGA group.

There was no significant difference in the two groups in the percentage of patients readmitted within 180 days of discharge (CGA: 16·7%; non-CGA: 16·4%; p = 0·118). The difference in length of time from discharge to readmission was also nonsignificant (CGA: median = 65 days; non-CGA: median = 67 days; p = 0·076). The percentages receiving rehabilitation intervention and home health care were both significantly higher in the CGA group than in the non-CGA group (30·3% vs. 24·9%, $p < 0.001$ and 8·3% vs. 7·6%, $p = 0.001$, respectively). A subgroup analysis of patients who were discharged to home with outpatient visits showed that the percentage receiving rehabilitation intervention remained significantly higher in the CGA group than in the non-CGA group (48·7% vs. 40·8%, $p < 0.001$). The E-value calculated using the relative risk for in-hospital mortality (1·15) was 1·57, indicating that an unobserved confounder with a relative risk of 1·57 on both treatment and outcome would be necessary to shift the result to null.

In the instrumental variable analysis, the mean percentage of patients who received CGA was 29·0% among those admitted in the 24 prefectures with higher rates of CGA and 9·1% among those admitted in the 23 prefectures with lower rates of CGA. The F-statistic was 12,831, indicating a strong instrument. Most variables were balanced between the two groups. In the two-stage residual inclusion model, CGA was associated with decreased in-hospital mortality after adjusting for all measured variables (odds ratio [OR] = 0·673, 95% CI: 0·537−0·842). CGA was also associated with the rate of readmission within 180 days of discharge (OR = 1·179, 95% CI: 1·049−1·326), the percentage receiving rehabilitation intervention (OR = 1·992, 95% CI: 1·796−2·210), and the percentage receiving home health care

(OR = 1·429, 95% CI: 1·176−1·737) for the propensity score-matched patients.

4. Discussion

This study was undertaken to describe the present implementation of CGA in Japan and to compare short-term outcomes between patients who received CGA and those who did not. We focused on older patients who were admitted for stroke and performed one-to-one propensity score matching to analyze the associations between CGA and outcomes among patients with balanced patient and hospital characteristics.

CGA was conducted for 21·3% of the older adult patients hospitalised for stroke. For the 53,861 propensity score-matched pairs, all-cause in-hospital mortality, 14-day mortality, 30-day mortality, and the proportion of patients with long-term hospitalization (> 60 days) were statistically significantly lower in the CGA group, compared with the non-CGA group. CGA was not significantly associated with readmission within 180 days of discharge or with the length of time from discharge to readmission. The percentages of patients receiving rehabilitation intervention and home health care were both significantly higher in the CGA group than in the non-CGA group. The results from the instrumental variable analysis were consistent with those from the propensity score analysis.

In Japan, CGA is performed for inpatients on admission to general medical wards and is expected to have a strong association with discharge support, rehabilitation, nutrition, and home health care. Although the setting of the present study differed from previous studies conducted in geriatric evaluation and management units, most of our findings were consistent with those of these previous

Table 1
Baseline patient characteristics in the unmatched and propensity score-matched groups.

| | Unmatched group | | | | | Propensity score-matched group | | | | |
| | non-CGA[a] | | CGA | | Standardised difference | non-CGA | | CGA | | Standardised difference |
	n	(%)	n	(%)		n	(%)	n	(%)	
Total	187,501		53,861			53,861		53,861		
Age, years										
65−69	28,339	(15·1)	7914	(14·7)	−1·2	7925	(14·7)	7914	(14·7)	−0·1
70−74	32,196	(17·2)	9104	(16·9)	−0·7	9308	(17·3)	9104	(16·9)	−1·0
75−79	36,666	(19·6)	10,637	(19·7)	0·5	10,535	(19·6)	10,637	(19·7)	0·5
80−84	38,883	(20·7)	11,283	(20·9)	0·5	11,195	(20·8)	11,283	(20·9)	0·4
≥ 85	51,417	(27·4)	14,923	(27·7)	0·6	14,898	(27·7)	14,923	(27·7)	0·1
Sex (male)	103,789	(55·4)	29,724	(55·2)	−0·3	29,806	(55·3)	29,724	(55·2)	−0·3
Annual hospital volume										
Low	7928	(4·2)	2747	(5·1)	4·1	2716	(5·0)	2747	(5·1)	0·3
Medium	47,990	(25·6)	10,876	(20·2)	−12·9	11,110	(20·6)	10,876	(20·2)	−1·1
High	131,583	(70·2)	40,238	(74·7)	10·2	40,035	(74·3)	40,238	(74·7)	0·9
Hospital category (number of general beds)										
Small hospital (≤ 99)	7158	(3·8)	2482	(4·6)	3·9	2362	(4·4)	2482	(4·6)	1·1
Medium hospital (100−499)	117,383	(62·6)	32,077	(59·6)	−6·3	31,856	(59·1)	32,077	(59·6)	0·8
Large hospital (≥ 500)	62,960	(33·6)	19,302	(35·8)	4·7	19,643	(36·5)	19,302	(35·8)	−1·3
Hospital DPC[b] category										
1—university hospital	14,010	(7·5)	1982	(3·7)	−16·6	1931	(3·6)	1982	(3·7)	0·5
2—advanced treatment hospital	29,031	(15·5)	9556	(17·7)	6·1	9780	(18·2)	9556	(17·7)	−1·1
3—normal hospital	144,460	(77·0)	42,323	(78·6)	3·7	42,150	(78·3)	42,323	(78·6)	0·8
Emergency admission	123,146	(65·7)	37,407	(69·5)	8·1	37,339	(69·3)	37,407	(69·5)	0·3
Consciousness level (Japan Coma Scale)										
Alert	87,091	(46·4)	25,276	(46·9)	1·0	25,754	(47·8)	25,276	(46·9)	−1·8
Dizzy	75,507	(40·3)	21,842	(40·6)	0·6	21,460	(39·8)	21,842	(40·6)	1·4
Somnolent	17,363	(9·3)	4844	(9·0)	−0·9	4776	(8·9)	4844	(9·0)	0·4
Coma	7540	(4·0)	1899	(3·5)	−2·6	1871	(3·5)	1899	(3·5)	0·3
Modified Rankin Scale										
0	87,058	(46·4)	23,833	(44·2)	−4·4	24,309	(45·1)	23,833	(44·2)	−1·8
1	31,082	(16·6)	9619	(17·9)	3·4	9551	(17·7)	9619	(17·9)	0·3
2	21,876	(11·7)	6513	(12·1)	1·3	6452	(12·0)	6513	(12·1)	0·3
3	17,277	(9·2)	5178	(9·6)	1·4	5035	(9·3)	5178	(9·6)	0·9
4	19,903	(10·6)	5744	(10·7)	0·2	5543	(10·3)	5744	(10·7)	1·2
5	10,305	(5·5)	2974	(5·5)	0·1	2971	(5·5)	2974	(5·5)	0·0
Date of stroke onset										
≤ 3 days	165,044	(88·0)	47,726	(88·6)	1·8	47,960	(89·0)	47,726	(88·6)	−1·4
4−7 days	8811	(4·7)	2880	(5·3)	3·0	2799	(5·2)	2880	(5·3)	0·7
≥ 8 days	11,290	(6·0)	2603	(4·8)	−5·2	2449	(4·5)	2603	(4·8)	1·4
Asymptomatic	2356	(1·3)	652	(1·2)	−0·4	653	(1·2)	652	(1·2)	0·0
Charlson comorbidity index										
0	117,797	(62·8)	32,564	(60·5)	−4·9	32,642	(60·6)	32,564	(60·5)	−0·3
1	12,887	(6·9)	3893	(7·2)	1·4	3941	(7·3)	3893	(7·2)	−0·3
2	43,851	(23·4)	13,506	(25·1)	3·9	13,524	(25·1)	13,506	(25·1)	−0·1
3	4732	(2·5)	1521	(2·8)	1·9	1441	(2·7)	1521	(2·8)	0·9
≥ 4	8234	(4·4)	2377	(4·4)	0·1	2313	(4·3)	2377	(4·4)	0·6
Barthel Index										
≤ 20	83,319	(44·4)	21,892	(40·6)	−7·7	21,608	(40·1)	21,892	(40·6)	1·1
21−40	18,017	(9·6)	5242	(9·7)	0·4	5179	(9·6)	5242	(9·7)	0·4
41−60	27,441	(14·6)	7901	(14·7)	0·1	7997	(14·8)	7901	(14·7)	−0·5
61−85	14,788	(7·9)	4638	(8·6)	2·6	4771	(8·9)	4638	(8·6)	−0·9
≥ 85	9331	(5·0)	2964	(5·5)	2·4	2969	(5·5)	2964	(5·5)	0·0
100	34,605	(18·5)	11,224	(20·8)	6·0	11,337	(21·0)	11,224	(20·8)	−0·5
Daily life independence level										
0	124,401	(66·3)	34,894	(64·8)	−3·3	35,238	(65·4)	34,894	(64·8)	−1·3
1	37,760	(20·1)	11,547	(21·4)	3·2	11,256	(20·9)	11,547	(21·4)	1·3
2	25,340	(13·5)	7420	(13·8)	0·8	7367	(13·7)	7420	(13·8)	0·3

[a] comprehensive geriatric assessment,.
[b] Diagnosis Procedure Combination.

studies [2-4]. Previous work has found that CGA in geriatric evaluation and management units in hospitals reduced mortality, and the present study showed a similar result (14% reduction per month in relative risk). Previous studies have indicated that CGA resulted in little or no difference in hospital readmission; [4] likewise, our study also showed no significant association between CGA and hospital readmission. There has been little evidence of the effect of CGA on length of hospital stay because of the small sample sizes of previous studies. In this large-scale study, there was a statistically significant difference in long-term hospitalization between CGA and non-CGA patients.

Among the outcomes that we examined, the effect size on rehabilitation was relatively large (CGA group: 30·3% vs. non-CGA group: 24·9%). According to a previous report, more than half of stroke patients in Japan died or required assistance or primary nursing care [22]. Interprofessional stroke care, including early rehabilitation intervention of the proper intensity, has an established effect not only on physical function but also on mortality [6,23−25]. The results of the present study suggest that CGA may help patients to receive better care, including rehabilitation. Additionally, part of the effect of CGA on mortality may be explained by an indirect effect mediated by an increase in rehabilitation.

Table 2
Treatment and care unit in the unmatched and propensity score-matched groups.

	Unmatched group					Propensity-matched group				
	non-CGA[a]		CGA		Standardised difference	non-CGA		CGA		Standardised difference
	n	(%)	n	(%)		n	(%)	n	(%)	
Total	187,501		53,861			53,861		53,861		
Drugs										
Antiplatelets	133,152	(71·0)	40,026	(74·3)	7·4	40,381	(75·0)	40,026	(74·3)	−1·5
Anticoagulants	128,237	(68·4)	35,589	(66·1)	−4·9	35,562	(66·0)	35,589	(66·1)	0·1
Edaravone	114,788	(61·2)	33,539	(62·3)	2·2	33,762	(62·7)	33,539	(62·3)	−0·9
Hyperosmolar solutions	18,113	(9·7)	5450	(10·1)	1·5	5333	(9·9)	5450	(10·1)	0·7
Thrombolytics	12,627	(6·7)	2847	(5·3)	−6·1	2751	(5·1)	2847	(5·3)	0·8
Surgery	5256	(2·8)	1282	(2·4)	−2·7	1232	(2·3)	1282	(2·4)	0·6
Unit										
High care unit	10,569	(5·6)	2076	(3·9)	−8·4	2039	(3·8)	2076	(3·9)	0·4
Stroke care unit	23,105	(12·3)	6718	(12·5)	0·5	6757	(12·5)	6718	(12·5)	−0·2
Intensive care unit	9124	(4·9)	2148	(4·0)	−4·3	2082	(3·9)	2148	(4·0)	0·6

[a] comprehensive geriatric assessment.

In addition, the need for home health care after discharge has been increasing. The concept of 'hospital at home' has spread around the world and has been shown to be associated with better patient outcomes [26–29]. Therefore, a higher proportion of patients receiving home health care would also be beneficial. The present study showed that CGA was associated with higher proportions of patients receiving rehabilitation and home health care, which suggests that CGA may help both medical staff and patients to maximize the use of these services. We also conducted a subgroup analysis of patients who were discharged to home with outpatient visits. In this relatively homogeneous group of patients, we found that the proportion receiving rehabilitation intervention remained higher for patients who received CGA than for those who did not receive CGA.

The strength of our study lies in the evaluation of a large sample using propensity score-matched pairs. Propensity score matching allows adjustment for measured potential confounding factors in the estimation of the influence of CGA on the outcomes. Treatments for stroke patients mostly follow the guidelines according to the date of onset and severity of symptoms [30]. Therefore, stroke is a suitable condition for evaluating the effects of CGA, adjusting for patient background using available data. To the best of our knowledge, this is the first large-scale study of CGA among stroke patients to show the association between CGA and length of hospital stay, rehabilitation intervention, and home health care.

A possible explanation for the present results may be that CGA helped to identify treatable health problems and appropriate goals, leading to better outcomes. CGA focuses not only on medical, psychological, and functional capabilities; it also considers social, financial, environmental, and spiritual components. This enables patients receiving CGA to get made-to-order treatment, care, and follow-up planning, including early discharge, rehabilitation, and home health care. Previous reports have shown that medical staff working in specialised wards were able to concentrate on enhancing their special knowledge and skills, leading to multidisciplinary team outcomes [31,32]. The current research extends previous work by demonstrating that CGA in general wards may have similar benefits to those of CGA in geriatric wards. These synergistic benefits and efforts in discharge planning may have contributed to a reduction in long-term hospitalization among patients receiving CGA.

Some limitations must be considered when interpreting the results of this study. First, although we used a nationwide database, the study was based on a retrospective observational design without randomization. Propensity score matching was used to adjust for differences in patient baseline characteristics, disease severity, and hospital information, but there may still be unmeasured confounders. Nevertheless, the consistent result of the instrumental variable analysis suggests that the effect of unmeasured confounders is minimal. Second, no validation study has been conducted exclusively for the diagnosis of stroke in the DPC data. However, a previous validation study reported a specificity of 98.9% and a positive predictive value of 86% for cerebrovascular diseases [12]. We therefore expected a high specificity for the diagnosis of stroke. Third, we used claims data to determine provision of CGA. The validity of claims data in identifying the provision of CGA has not been evaluated, and there is a possibility of CGA being conducted without assessing the associated fee. Furthermore, information such as the presence of geriatric evaluation and management units, the number of gerontologists at the hospital, and the quality of CGA provided could not be evaluated with the present database. Fourth, the database also lacked records on the time interval between procedures such as drug administration and CGA and on whether the patient had received CGA in the past. Finally, we had no information about the family environment, caregiver, or economic situation of the patient.

Table 3
Comparisons of outcomes between propensity score-matched groups.

	non-CGA[a]	CGA	p
Primary outcomes			
14-day mortality	0·9% (505/53,861)	0·7% (365/53,861)	< 0·001
30-day mortality	2·1% (1157/53,861)	1·8% (993/53,861)	< 0·001
In-hospital mortality	4·1% (2213/53,861)	3·6% (1928/53,861)	< 0·001
Length of hospital stay, days—median (interquartile range)	20 (12−36)	20 (12−35)	> 0·999
Long-term hospitalization (> 60 days)	10·1% (5229/53,861)	8·7% (4536/53,861)	< 0·001
Secondary outcomes			
Readmission within 180 days of discharge	16·4% (8493/51,648)	16·7% (8681/51,933)	0·118
Length from discharge to readmission, days—median (interquartile range)	67 (25−139)	65 (23−134)	0·076
Rehabilitation	24·9% (12,871/51,648)	30·3% (15,742/51,933)	< 0·001
Home health care	7·6% (3940/51,648)	8·3% (4311/51,933)	0·001

Data are presented as % (n) unless otherwise stated.
[a] comprehensive geriatric assessment.

Despite the incentive of the fee payment, the rate of CGA provision found in this study was low. In a previous survey, reasons for not performing CGA were reported as a lack of knowledge on how to perform CGA, the time-consuming nature of CGA, staff shortages, and low cost-effectiveness [33]. These obstacles need to be dealt with to increase the use of CGA. The number of older adults has grown rapidly in industrialised countries, and health services for these individuals are becoming increasingly important. CGA has spread worldwide, and the present findings in Japan, one of the most aged countries in the world, can be of use for health policy in other international contexts.

In this study, we focused on stroke patients, as a group of patients with frailty or disability. Using a large national inpatient database in Japan, we found that CGA was significantly associated with all-cause mortality, length of hospital stay, length of time from discharge to readmission, and the proportions of patients receiving rehabilitation intervention and/or home health care. Therefore, the use of CGA for older stroke inpatients should be promoted. Further studies investigating whether these findings can be applied to patients with other conditions or exploring which components of CGA are the most important may lead to the development of more effective CGA.

Declaration of Competing Interest

We declare no potential conflicts of interest.

Data sharing

The datasets analysed during the current study are not publicly available due to contracts with the hospitals providing data to the database.

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