Temporal trends and geographical disparties in comprehensive stroke centre capabilities in Japan from 2010 to 2018

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ABSTRACT

Objectives Comprehensive stroke centre (CSC) capabilities are associated with reduced in-hospital mortality due to acute stroke. However, it remains unclear whether there are improving trends in the CSC capabilities or how hospital-related factors determine quality improvement. This study examined whether CSC capabilities changed in Japan between 2010 and 2018 and and whether any changes were influenced by hospital characteristics.

Design A hospital-based cross-sectional study.

Setting We sent out questionnaires to the training institutions of the Japan Neurosurgical Society and Japan Stroke Society in 2010, 2014 and 2018.

Participants 749 hospitals in 2010, 532 hospitals in 2014 and 786 hospitals in 2018 participated in the J-ASPECT study, a nationwide survey of acute stroke care capacity for proper designation of a comprehensive stroke centre in Japan.

Main outcome measures CSC capabilities were assessed using the validated scoring system (CSC score: 1–25 points) in 2010, 2014 and 2018 survey. The effect of hospital characteristics was examined using multiple logistic regression analysis.

Results Among the 323 hospitals that responded to all surveys, the implementation of 13 recommended items increased. The CSC score (median and IQR) was 16 (13–19), 18 (14–20) and 19 (15–21) for 2010, 2014 and 2018, respectively ($p<0.001$). There was a ≥20% increase in six items (eg, endovascular physicians, stroke unit and interventional coverage 24/7), and a ≤20% decrease in community education. A lower baseline CSC score (OR: 0.82, 95% CI 0.75 to 0.9), the number of beds≥500 (OR: 3.9, 95% CI 1.2 to 13.0) and the number of stroke physicians (7–9) (OR: 2.6, 95% CI 1.1 to 6.3) were associated with improved CSC capabilities, independent of geographical location.

Conclusions There was a significant improvement in CSC capabilities between 2010 and 2018, which was mainly related to the availability of endovascular treatment and multidisciplinary care. Our findings may be useful to determine which hospitals should be targeted to improve CSC capabilities in a defined area.

Strengths and limitations of this study

- A large-scale, representative hospitals of Japan provided data on temporal trends in the comprehensive stroke centre (CSC) capabilities for this cross-sectional study.
- Hospitals actively working to improve stroke care are more likely to respond to the questionnaire, which may lead to information bias.
- The CSC score was a significant composite measure to influence in-hospital mortality of acute stroke, but little information was established on the influence of specific items.

INTRODUCTION

Stroke is the third leading cause of death and a leading cause of long-term disability in Japan. Primary and comprehensive stroke centres (CSCs) were developed to provide optimal implementation of intravenous recombinant tissue plasminogen activator (rt-PA) infusion and more intensive stroke care that includes endovascular and neurosurgical treatment.[1 2] Organised care in a stroke unit is associated with better quality of care and reduced death and dependency.[3 4] In addition to the influence of this process, previous studies have shown that patient outcomes associated with stroke and cardiovascular diseases are influenced by the hospital case volume,[5 6] the number of physicians, and the geographical locations of the facility.[7] Progressive rural–urban disparities in acute stroke care have been reported in the USA,[8] but it is not known whether such disparity exists in other countries.

In 2010, we launched the J-ASPECT study, a nationwide survey of acute stroke care capacity for proper designation of a comprehensive stroke centre in Japan.[9 10] The J-ASPECT stroke database is a hospital-based, Japan-wide stroke registry. We demonstrated significant geographical differences in CSC capabilities in 2010,[9] and that CSC capabilities of a facility are associated with reduced in-hospital mortality from acute stroke.[10] Thus, continuous monitoring of the CSC capabilities may be clinically meaningful to improve stroke outcomes.[10 11] Since 2010, we have conducted nationwide benchmark analyses to allow participating hospitals to facilitate improvement of stroke care. However, it remains unclear whether there are improving trends in the CSC capabilities or how hospital-related factors determine quality improvement.

AIMS

We aimed to examine whether CSC capabilities in Japan changed from 2010 to 2018 and whether any recorded changes were influenced by hospital characteristics.

METHODS

Institutional survey of CSC capabilities

This cross-sectional survey used the Diagnosis Procedure Combination (DPC) discharge database from participating institutions in the J-ASPECT study. Participation in the J-ASPECT study was voluntary. Of the 1369 training institutions certified by the Japan Neurosurgical Society, the Japanese Society of Neurology and the Japan Stroke Society, 621 agreed to participate in this study. The J-ASPECT study group analysed the DPC database to gain new clinical insights on ischaemic and haemorrhagic stroke, an approach we applied again for this cross-sectional survey. In this study, we sent out questionnaires to the training institutions of all three societies in 2010, 2014 and 2018 to assess CSC capabilities. The CSC capabilities of each facility were assessed with a validated scoring system (CSC score), using 25 items recommended by the Brain Attack Coalition.[2 5–7]

All items were classified into five categories: personnel, diagnostic, specific expertise, infrastructure and education. A score of 1 was assigned for meeting each item, yielding a total CSC score of up to 25. Content, constructs and predictive validity of this scoring system have been previously reported.[12 13]

Other hospital characteristics

Hospital characteristics, including number of beds, annual stroke hospitalisations, stroke physicians, academic status, adoption of the DPC-based payment system,[9] and geographic location were obtained from the 2010 survey. The geographic location was classified according to urban employment areas (UEAs) divided into Metropolitan Employment Areas (MEAs) and Micropolitan Employment Areas (McEAs).[9] The MEAs were further classified into central and outlying areas based on the commuting pattern of their inhabitants. The details of UEAs, such as total population or total land area, have been previously described.[10]

Statistical analysis

To explore trends in CSC capabilities, we examined implementation of the 25 items and the CSC score in the 323 consecutively participating hospitals that responded to all surveys. To examine the influence of hospital-related factors on the change in CSC capabilities, we divided the hospitals into those with or without a temporal improvement of CSC score (≥1-point increase between 2010 and 2018). The increase of 'one point' was set based on our previous report on the CSC score.[11] In that study, we showed that even a small preceding improvement of the CSC score was associated with reduced in-hospital mortality, reduced poor outcomes and higher use of acute reperfusion therapy in acute ischaemic stroke (AIS) patients; our findings also suggested the difficulty in improving the CSC score in a relatively short time period.

We used a χ^2 test to detect differences between consecutively participating hospitals and other hospitals in the number of each hospital item. We did not perform multiple tests. Wilcoxon rank sum test was used to compare total CSC scores between consecutively participating hospitals and other hospitals.

To explore the influence of hospital-related factors on temporal improvement of CSC capabilities, multiple logistic regression models were used. To assess selection bias, we compared hospital characteristics between consecutively participating hospitals with the others. We also examined the relationship between 'number of physicians' and 'hospital size' and the relationship between 'number of physicians' and 'CSC score' using χ^2 tests. All analyses were performed using the JMP Statistical Software V.12 (SAS Institute, Cary, North Carolina, USA). P values of <0.05 were considered statistically significant.

Patient and public involvement

The data for this study are based on information collected by the J-ASPECT study. Patients and the public were not involved in the development of this study.

RESULTS

Trends in the CSC capabilities from 2010 to 2018

A total of 749, 532 and 786 hospitals responded to the survey in 2010, 2014 and 2018, respectively. The implementation rates of each item are shown in table 1. The median (IQR) of the CSC scores was 14 (11–18), 17 (13–19) and 17 (12–20.3) for each year, respectively (table 1).

Among consecutively participating hospitals, there was an increase in implementation rates of the 13 items, and the CSC scores were (median and IQR): 16 (13–19), 18 (14–20) and 19 (15–21) for 2010, 2014 and 2018, respectively (p<0.001) (table 1). A marked increase (≥20%) was noted in six items related to endovascular treatment (endovascular physicians and interventional coverage 24/7) and multidisciplinary care (stroke unit, specialists of emergency medicine and physical medicine/rehabilitation, and stroke rehabilitation nurses).

Table 1 Number (percentage) of the responding hospitals fulfilling the recommended items of comprehensive stroke care capabilities

		2010				2014				2018			
Components	**Items**	**All participating hsps (n=749)**	**Consecutively participating hsps (n=323)**	**Other hsps (n=426)**	**P value**	**All participating hsps (n=532)**	**Consecutively participating hsps (n=323)**	**Other hsps (n=209)**	**P value**	**All participating hsps (n=786)**	**Consecutively participating hsps (n=323)**	**Other hsps (n=464)**	**P value**
Personnel	Neurologists	358 (47.8)	176 (54.5)	182 (42.7)	0.001	283 (53.2)	177 (54.8)	106 (50.7)	0.357	452 (57.5)	210 (65.0)	242 (52.2)	<0.001
	Neurosurgeons	694 (92.7)	314 (97.2)	380 (89.2)	<0.001	515 (96.8)	317 (98.1)	198 (94.7)	0.03	754 (95.9)	317 (98.1)	437 (94.2)	0.006
	Endovascular physicians	272 (36.3)	146 (45.2)	126 (29.6)	<0.001	280 (52.6)	196 (60.7)	84 (40.2)	<0.001	428 (54.4)	211 (65.3)	217 (46.8)	<0.001
	Emergency medicine	162 (21.6)	96 (29.7)	66 (15.5)	<0.001	207 (38.9)	146 (45.2)	61 (29.2)	<0.001	427 (54.3)	205 (63.5)	222 (63.5)	<0.001
	Physical medicine and rehabilitation	113 (15.1)	61 (18.9)	52 (12.2)	0.011	143 (26.9)	95 (29.4)	48 (23.0)	0.102	313 (39.8)	137 (42.4)	176 (37.9)	0.206
	Rehabilitation therapy	742 (99.1)	321 (99.4)	421 (98.8)	0.435	529 (99.4)	321 (99.4)	208 (99.5)	0.832	779 (99.1)	321 (99.4)	458 (98.7)	0.354
	Stroke rehabilitation nurses	102 (13.6)	48 (14.9)	54 (12.7)	0.388	157 (29.5)	116 (35.9)	41 (19.6)	<0.001	285 (36.2)	146 (45.2)	139 (30.0)	<0.001
Diagnostic	CT	742 (99.1)	322 (99.7)	420 (98.6)	0.122	527 (99.1)	322 (99.7)	205 (98.1)	0.061	763 (97.1)	322 (99.7)	441 (85.0)	<0.001
	MRI with diffusion	647 (86.4)	291 (90.1)	356 (83.6)	0.01	504 (94.7)	311 (96.3)	193 (92.3)	0.047	732 (93.1)	314 (97.2)	418 (90.1)	<0.001
	Digital cerebral angiography	602 (80.3)	288 (89.2)	314 (73.7)	<0.001	476 (89.4)	305 (94.4)	171 (81.8)	<0.001	638 (81.2)	299 (92.6)	399 (73.1)	<0.001
	CT angiography	627 (83.7)	289 (89.5)	338 (79.3)	<0.001	492 (92.5)	305 (94.4)	187 (89.5)	0.034	701 (89.2)	309 (95.7)	392 (84.5)	<0.001
	Carotid duplex ultrasound	257 (34.3)	126 (39.0)	131 (30.8)	0.018	219 (41.2)	153 (47.4)	66 (31.6)	<0.001	343 (43.6)	169 (52.3)	174 (37.5)	<0.001
	TCD	121 (16.2)	70 (21.7)	51 (12.0)	<0.001	123 (23.1)	87 (26.9)	36 (17.2)	<0.010	162 (20.6)	95 (29.4)	67 (14.4)	<0.001
Specific expertise	Carotid endarterectomy	603 (80.5)	292 (90.4)	311 (73.0)	<0.001	458 (86.1)	288 (89.2)	170 (81.3)	0.011	613 (78.0)	284 (87.9)	329 (70.9)	<0.001
	Clipping of intracranial aneurysm	685 (91.5)	314 (97.2)	371 (87.1)	<0.001	504 (94.7)	315 (97.5)	189 (90.4)	<0.001	706 (89.8)	314 (97.2)	392 (84.5)	<0.001
	Haematoma removal/draining	689 (92.0)	315 (97.5)	374 (87.8)	<0.001	505 (95.0)	315 (97.5)	190 (90.9)	<0.001	718 (91.3)	314 (97.2)	404 (87.1)	<0.001
	Coiling of intracranial aneurysm	360 (48.1)	192 (59.4)	168 (39.4)	<0.001	332 (62.4)	223 (69.0)	109 (52.2)	<0.001	448 (57.0)	223 (69.0)	225 (48.5)	<0.001
	Intra-arterial reperfusion therapy	498 (66.5)	245 (75.9)	253 (59.4)	<0.001	398 (74.8)	261 (80.8)	137 (65.6)	<0.001	510 (64.9)	247 (76.5)	263 (56.7)	<0.001

Continued

Table 1 Continued

Components	Items	2010 All participating hsps (n=749)	2010 Consecutively participating hsps (n=323)	2010 Other hsps (n=426)	2010 P value	2014 All participating hsps (n=532)	2014 Consecutively participating hsps (n=323)	2014 Other hsps (n=209)	2014 P value	2018 All participating hsps (n=786)	2018 Consecutively participating hsps (n=323)	2018 Other hsps (n=464)	2018 P value
Infrastructure	Stroke unit	132 (17.6)	74 (22.9)	58 (13.6)	<0.001	202 (38.0)	136 (42.1)	66 (31.6)	0.015	342 (43.5)	171 (52.9)	171 (36.9)	<0.001
	Intensive care unit	445 (59.4)	214 (66.3)	231 (54.2)	<0.001	362 (68.0)	224 (69.4)	138 (66.0)	0.422	467 (59.4)	220 (68.1)	247 (53.2)	<0.001
	Operating room staffed 24/7	451 (60.2)	230 (71.2)	221 (51.9)	<0.001	339 (63.7)	239 (74.0)	100 (47.9)	<0.001	487 (62.0)	243 (75.2)	244 (52.6)	<0.001
	Interventional services coverage 24/7	279 (37.3)	147 (45.5)	132 (31.0)	<0.001	317 (59.6)	218 (67.5)	99 (47.4)	<0.001	452 (57.5)	219 (67.8)	233 (50.2)	<0.001
	Stroke registry	235 (31.4)	133 (41.2)	102 (23.9)	<0.001	260 (48.9)	172 (53.3)	88 (42.1)	0.012	349 (44.4)	164 (50.8)	185 (39.9)	0.003
Education	Community education	369 (49.3)	188 (58.2)	181 (42.5)	<0.001	144 (27.1)	91 (28.2)	53 (25.4)	0.476	204 (26.0)	98 (30.3)	106 (22.8)	0.018
	Professional education	436 (58.2)	207 (64.1)	229 (53.8)	0.005	326 (61.3)	208 (64.4)	118 (56.5)	0.066	429 (54.6)	184 (57.0)	245 (52.8)	0.249
Total CSC score													
Median (IQR)		14 (11–18)	16 (13–19)	13 (10–17)	<0.001	17 (13–19)	18 (14–20)	15 (12–18)	<0.001	17 (12–20)	19 (15–21)	15 (10–19)	<0.001

CSC, comprehensive stroke centre; hsps, hospitals; TCD, transcranial Doppler.

Table 2 Characteristics of comprehensive stroke care capabilities according to the geographical differences

	2010				2018			
	MEA central (n=186)	MEA outlying (n=79)	McEA (n=35)	P value	MEA central (n=186)	MEA outlying (n=79)	McEA (n=35)	P value
Personnel								
Neurologists	115 (61.8)	44 (55.7)	10 (28.6)	0.001	133 (71.5)	55 (69.6)	14 (40.0)	0.001
Neurosurgeons	181 (97.3)	77 (97.5)	34 (97.1)	0.995	183 (98.4)	78 (98.7)	34 (97.1)	0.826
Endovascular physicians	101 (54.3)	31 (39.2)	8 (22.9)	<0.001	136 (73.1)	49 (62.0)	14 (40.0)	<0.001
Emergency medicine	57 (30.7)	25 (31.7)	7 (20.0)	0.406	122 (65.6)	54 (68.4)	16 (45.7)	0.052
Physical medicine and rehabilitation	36 (19.4)	16 (20.3)	5 (14.3)	0.740	83 (44.6)	42 (53.2)	3 (8.6)	<0.001
Rehabilitation therapy	185 (99.5)	78 (98.7)	35 (100)	0.701	185 (99.5)	78 (98.7)	35 (100)	0.701
Stroke rehabilitation nurses	33 (17.8)	9 (11.4)	1 (2.9)	0.049	90 (48.4)	41 (51.9)	9 (25.7)	0.027
Diagnostic								
CT	185 (99.5)	79 (100.0)	35 (100.0)	0.735	185 (100)	79 (100)	35 (100)	0.735
MRI with diffusion	167 (89.8)	69 (87.3)	33 (94.3)	0.530	179 (96.2)	78 (98.7)	35 (100)	0.299
Digital cerebral angiography	165 (88.7)	70 (88.6)	34 (97.1)	0.303	168 (90.3)	76 (96.2)	33 (94.3)	0.232
CT angiography	163 (87.6)	72 (91.1)	32 (91.4)	0.627	176 (94.6)	77 (97.5)	34 (97.1)	0.525
Carotid duplex ultrasound	71 (38.1)	30 (38.0)	14 (40.0)	0.977	95 (51.1)	48 (60.8)	15 (42.9)	0.164
TCD	43 (23.1)	18 (22.8)	3 (8.6)	0.146	54 (29.0)	29 (36.7)	5 (14.3)	0.052
Specific expertise								
Carotid endarterectomy	173 (93.0)	68 (86.1)	32 (91.4)	0.196	166 (89.3)	71 (89.9)	28 (80)	0.260
Clipping of intracranial aneurysm	183 (98.4)	75 (94.9)	34 (97.1)	0.280	181 (97.3)	77 (97.5)	34 (97.1)	0.995
Haematoma removal/draining	183 (98.4)	76 (96.2)	34 (97.1)	0.546	182 (97,9)	77 (97.5)	35 (94.3)	0.485
Coiling of intracranial aneurysm	119 (64.0)	46 (58.2)	13 (37.1)	0.012	143 (76.9)	49 (62.0)	17 (48.6)	<0.001
Intra-arterial reperfusion therapy	142 (76.3)	58 (73.4)	27 (77.1)	0.859	153 (82.3)	57 (72.2)	22 (62.9)	0.019
Infrastructure								
Stroke unit	50 (26.9)	17 (21.5)	2 (5.7)	0.023	106 (57.0)	44 (55.7)	13 (37.1)	0.093
Intensive care unit	123 (66.1)	54 (68.4)	21 (60.0)	0.685	134 (72.0)	54 (68.4)	18 (51.4)	0.054
Operating room staffed 24/7	143 (76.9)	59 (74.7)	15 (42.9)	<0.001	148 (79.6)	56 (70.9)	22 (62.9)	0.062
Interventional services coverage 24/7	103 (55.4)	30 (38.0)	6 (17.1)	<0.001	133 (71.5)	54 (68.4)	18 (51.4)	0.064
Stroke registry	81 (43.6)	31 (29.1)	15 (42.9)	0.808	93 (50.0)	47 (59.5)	15 (42.9)	0.199
Education								
Community education	110 (59.1)	53 (67.1)	17 (48.6)	0.164	55 (29.6)	28 (35.4)	8 (22.9)	0.377
Professional education	125 (67.2)	53 (67.1)	17 (48.6)	0.095	105 (56.5)	47 (59.5)	17 (48.6)	0.555

McEA, Microplitan Employment Area; MEA, Metropolitan Employment Area; TCD, transcranial Doppler.

In addition, a moderate increase (≤20%) was noted in seven items: neurologists, 24/7 availability of diffusion-weighted MRI, digital and CT angiography, carotid ultrasound, coiling of an intracranial aneurysm and implementation of stroke registry. In contrast, there was a marked decrease (≤20%) in community education.

Geographical differences in CSC capabilities between 2010 and 2018

Among the seven items with significant geographical differences in 2010, all items in the personal component still showed a gap, despite overall improvement at all locations in 2018 (table 2). In contrast, geographical differences in all infrastructure items diminished with overall improvement and a marked improvement in the McEA in 2018.

Over the study period, geographical differences emerged in intra-arterial reperfusion therapy and the number of specialists in physical medicine/rehabilitation. The remaining item, coiling of intracranial aneurysms, showed no changes.

Influence of hospital characteristics on change in CSC capabilities

Among consecutively participating hospitals, 23 were excluded due to the missing data. Temporal improvement of CSC capabilities between 2010 and 2018 was noted in 198 hospitals (66.0%). As for hospital characteristics,

Table 3 Hospital characteristics those with/without temporal improvement of the CSC capabilities

Hsp-related factors in 2010	All consecutively participating hsps (n=300)	Improvement hsps (n=198)	No improvement hsps (n=102)	P value*
Hsp locations				0.478
MEA central	186 (62.0)	121 (61.1)	65 (63.7)	
MEA outlying	79 (26.3)	56 (28.3)	23 (22.6)	
McEA	35 (11.7)	21 (10.6)	14 (13.7)	
CSC score in 2010				
Median (IQR)	16 (13 to 19)	16 (13 to 18)	17 (13 to 20)	0.032
Academic hospital	58 (19.3)	42 (21.2)	16 (15.7)	0.251
DPC hospital	225 (75.0)	145 (73.2)	80 (78.4)	0.325
Number of hospital beds				0.016
1–99	17 (5.7)	9 (4.6)	8 (7.8)	
100–299	68 (22.7)	37 (18.7)	31 (30.4)	
300–499	96 (32.0)	62 (31.1)	34 (33.3)	
≥500	119 (39.7)	90 (45.5)	29 (28.4)	
Annual stroke case volume				0.915
0–99	34 (11.3)	21 (10.6)	13 (12.8)	
100–199	73 (24.3)	47 (23.7)	26 (25.5)	
200–299	67 (22.3)	45 (22.7)	22 (21.6)	
≥300	126 (42.0)	85 (42.9)	41 (40.2)	
Number of stroke physician volume				
Median (IQR)	6 (3 to 9)	6 (3.8 to 9)	5 (3 to 9.3)	0.139
Number of stroke physician volume quartile				
Q1 (0–3)	82 (27.3)	49 (24.8)	33 (32.4)	
Q2 (4–6)	68 (22.7)	43 (21.7)	25 (24.5)	
Q3 (7–9)	80 (26.7)	61 (30.8)	19 (18.6)	
Q4 (≥10)	70 (23.3)	45 (22.7)	25 (24.5)	
Number of stroke physician volume tertile				
T1 (0–4)	114 (38.0)	72 (36.4)	42 (41.2)	
T2 (4–8)	96 (32.0)	63 (31.8)	33 (32.4)	
T3 (≥9)	90 (30.0)	63 (31.8)	27 (26.5)	

*P value: improvement versus no improvement hsps.
CSC, comprehensive stroke centre; DPC, Diagnostic Procedure Combination; Hsp, hospital; McEA, Micropolitan Employment Area; MEA, Metropolitan Employment Area.

there were weakly significant differences in bed number (p=0.016) and CSC score in 2010 (p=0.032) between the two groups on univariable analysis (table 3).

In the logistic regression analyses, the following variables had an association with temporal improvement of CSC capabilities (table 4): a lower baseline CSC score (OR: 0.82, 95% CI 0.75 to 0.9), bed volume ≥500 (OR: 3.90, 95% CI 1.17 to 13.0) and moderate (7–9) number of stroke physicians (OR: 2.63, 95% CI 1.10 to 6.27). In contrast, geographical location, academic status, DPC-based payment system and case volume of stroke did not show a significant association. We also performed the logistic regression analysis adjusting tertile, instead of quartile, of stroke physician volume in addition to the other adjusting factors. Except for Q3 of stroke physician volume, we found very similar results (online supplementary etable 1). Additionally, there was a significant relationship between hospital size and number of physicians (p<0.001), and between CSC score and number of physicians (p<0.001).

Selection bias

The response rates of the 2010, 2014 and 2018 surveys were 55.0%, 39.7%, and 49.9%, respectively. We found that a selection bias did exist; in fact, the total CSC scores and most of the implementation rates of each item were significantly higher for the consecutively participating hospitals than for the others in all three surveys (table 1).

Table 4 Multivariable analysis of the impact of hospital characteristics on one-point increases of the CSC score

Hospital-related factors in 2010	OR	95% CI	P value*
Hospital locations			
MEA central	Ref.		
MEA outlying	1.42	0.76 to 2.65	0.269
McEA	0.82	0.36 to 1.86	0.632
CSC score in 2010	0.82	0.75 to 0.90	<0.001
Academic hospital	1.37	0.54 to 3.48	0.506
DPC hospital	0.77	0.41 to 1.42	0.397
Number of beds			
1–99	ref.		
100–299	1.16	0.37 to 3.66	0.794
300–499	1.68	0.56 to 5.10	0.358
≥500	3.9	1.17 to 13.00	0.027
Annual stroke case volume			
1–99	ref.		
100–199	1.62	0.64 to 4.07	0.305
200–299	2.41	0.89 to 6.49	0.083
≥300	2.74	0.99 to 7.54	0.051
Number of stroke physician volume quartile			
Q1 (0–3)	Ref.		
Q2 (4–6)	1.77	0.81 to 3.88	0.153
Q3 (7–9)	2.63	1.10 to 6.27	**0.030**
Q4 (≥10)	1.58	0.57 to 4.38	0.380

*P value: improvement versus no improvement hospitals.
CSC, comprehensive stroke centre; DPC, Diagnostic Procedure Combination; McEA, Micropolitan Employment Area; MEA, Metropolitan Employment Area.

Consecutively participating hospitals were more likely to be MEA central, be academic, have a larger number of hospital beds, have a higher annual stroke admission rate and have more stroke physicians (online supplementary etable 2).

DISCUSSION

We found an overall improvement in CSC capabilities between 2010 and 2018 and and different trends in geographical disparities for different items. Hospitals with a higher number of hospital beds, an intermediate number of stroke physicians and a lower baseline CSC score had a higher likelihood of improving their CSC capabilities.

Temporal changes to CSC capabilities

In addition to a significant increase in CSC capabilities, there was a marked increase in implementation of the items, mainly related to endovascular treatment and multidisciplinary care. Of note, we previously showed that interventional 24/7 coverage and the presence of physical medicine/rehabilitation specialists were associated with reduced in-hospital mortality for patients with subarachnoid haemorrhage, whereas availability of neurologists and stroke units were associated with reduced in-hospital mortality and better functional outcomes, respectively, for those with ischaemic stroke.[13]

These findings are consistent with those of prior studies, which have shown that admission to a stroke unit with organised stroke care is associated with better quality of care and outcomes in those who experience an acute stroke.[3 14] Although the use of mechanical thrombectomy for large vessel AIS has been rapidly increasing, only 3.3% of 15.1% potentially eligible AIS patients received it in 2016.[15] Improvement of CSC capabilities, especially related to endovascular treatment and multidisciplinary care, should contribute to improved quality of care and outcomes in patients with acute stroke.

The decreased implementation of community education observed in this study may be explained by the limited number of stroke physicians available for this purpose due to an increased burden of stroke care (eg, emergent endovascular calls).[16] Stroke educational campaigns have the potential to improve knowledge and awareness, but public campaigns are usually expensive and short lived, and may not achieve any significant improvement.[17]

Diminished and emerging geographical disparities

Determining rural/urban differences in CSC capabilities may support the development of targeted interventions to improve stroke care and outcomes in rural areas. We found differing trends in implementation of the items according to personnel and infrastructure components. Rural areas are associated with reduced access to optimal stroke care and a lower use of acute stroke intervention.[18] The diminished disparities in implementation of stroke units in this study might result in a higher use of rt-PA infusion in rural areas.[19]

The emerging disparities in implementation of intra-arterial reperfusion therapy deserve some attention. Since the evidence regarding the efficacy of acute endovascular reperfusion therapy was established in 2015,[20] relocation of relevant specialists might have occurred from rural to urban areas to meet the urgent need created by more widespread use. In addition, a high prevalence of neurointerventional physician burnout may require centralisation of acute endovascular reperfusion treatment.[21]

Influence of hospital-related factors on improvement of CSC capabilities

Our study showed the impact of specific hospital-related factors on improvement of CSC capabilities, which may be useful to determine which hospitals should be targeted to improve CSC capabilities, and in what regions. In rural areas, where medical resources are limited, centralisation of acute stroke care in large hospitals may be needed. We also found a significant relationship between CSC score and number of physicians. This means that, in 2010, institutions with more physicians tended to have higher baseline CSC scores. The reason that a physician volume of more than 10 did not affect the improvement of the CSC score may be explained by the ceiling effect of a high baseline CSC score in 2010.

Limitations

There are several limitations of this study. First, since the total CSC scores and most of the implementation rates of each item were significantly higher for the consecutively participating hospitals than for the others in all three surveys, our findings may have included biased information. Second, the CSC score was a significant composite measure to influence in-hospital mortality of acute stroke, but little information was established on the influence of specific items. Third, we did not determine the influence of unmeasured confounders. Fourth, the CSC score is a self-reported questionnaire rather than the result of any formal certification process. In Japan, the official certification process for primary stroke centres just began in 2019. The criteria for CSC certification is now under discussion by the Japan Stroke Society. The results of this study could have a significant impact on the recommended items and criteria for the designation of official CSCs in Japan. After the official certification process for CSCs is implemented, we plan to reassess the effect of CSC capabilities on AIS patients. Finally, the 2014 data did not factor into this analysis because of the small number of participants in that year. Further research is required to examine the effect of 2014 data on the analysis.

CONCLUSIONS

The CSC capabilities in Japan improved between 2010 and 2018, especially related to endovascular treatment and multidisciplinary care. Our findings may be useful to determine which hospitals should be targeted to improve CSC capabilities in a defined area.

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Contributors AKurogi and KI drafted the manuscript. AN, KN, AKada, DO, AH and KI were involved in study concept, design and obtaining funding. AKada, DO, AH, KO, YS, TK, KA and KI were involved in the analysis of data. KO, YS, TK and KI were involved in the acquisition of data. All authors reviewed the study report, made comments or suggestions on the manuscript drafts, and approved the final version.

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