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Temporal trends and geographical disparities in comprehensive stroke center capabilities in Japan from 2010 to 2018

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5 Temporal trends and geographical disparities in comprehensive stroke center
6 capabilities in Japan from 2010 to 2018
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ABSTRACT

Objectives: Comprehensive stroke center (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 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 in 2010, 532 in 2014 and 786 in 2018 hospitals that participate in the J-ASPECT Study.

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 14 recommended items increased. The CSC score (median, interquartile range) was 16 (13-19), 18 (14-20), 19 (15-21), for 2010, 2014, and 2018, respectively (p for trend < 0.001). There was a $\geq 20\%$ increase in six items (e.g. endovascular physicians, stroke unit, and interventional coverage 24/7), and a $\leq 20\%$ decrease in community education.

A lower baseline CSC score (odds ratio 0.82, [95% confidence interval] 0.75-0.9), the

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number of beds ≥ 500 (3.9 [1.2–13.0]), and the number of stroke physicians (7-9) (2.6 [1.1-6.3]) was 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. Hospital characteristics may be considered to further improve systems of stroke care in light of a limited medical resources in a defined area.

Strengths and limitations of this study:

- A large-scale, representative hospitals of Japan provided data on temporal trends in the 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 centers (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} Organized care in a stroke unit is associated with better quality of care, and reduced death and dependency.^{3, 4} Previous studies showed that patient outcomes associated with stroke and cardiovascular diseases are influenced by the hospital case volume,^{5, 6} number of physicians, and geographical locations of the facility⁷. Progressive rural-urban disparities in acute stroke care has been reported in the United States,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 center 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

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5 We aimed to examine whether CSC capabilities in Japan changed from 2010 to 2018
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7 and whether any recorded changes were influenced by hospital characteristics.
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10 11 12 **METHODS**

13 14 15 **Institutional survey of CSC capabilities**

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17 The J-ASPECT Study was launched in collaboration with the Japan Neurosurgical
18 Society and Japan Stroke Society, and participation was voluntary. In this study, we
19 sent out questionnaires to the training institutions of both Societies in 2010, 2014 and
20 2018 to assess CSC capabilities. The CSC capabilities of each facility were assessed
21 with a validated scoring system (CSC score), using 25 items recommended by the Brain
22 Attack Coalition. (2, 5-7)
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30 All items were classified into five categories: personnel, diagnostic, specific expertise,
31 infrastructure, and education. A score of 1 was assigned for meeting each item, yielding
32 a total CSC score of up to 25. Content, constructs, and predictive validity of this scoring
33 system have been reported.^{10, 11}
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42 43 **Other hospital characteristics**

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45 Hospital characteristics including number of beds, annual stroke hospitalizations, stroke
46 physicians, academic status, adoption of the Diagnosis Procedure Combination
47 (DPC)-based payment system⁹, and geographic location were obtained from the 2010
48 survey. The geographic location was classified according to urban employment areas
49 (UEAs) divided into Metropolitan Employment Areas (MEAs) and Micropolitan
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7 Employment Areas (McEAs).⁹ The MEAs were further classified into central and
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10 outlying areas based on the commuting pattern of their inhabitants.
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14 **Statistical analysis**

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18 To explore trends in CSC capabilities, we examined implementation of the 25 items and
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21 the CSC score in the 323 consecutively participating hospitals that responded to all
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24 surveys. To examine the influence of hospital-related factors on the change in CSC
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27 capabilities, we divided the hospitals into those with or without a temporal
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30 improvement of CSC score (≥ 1 point increase between 2010 and 2018). Hospital
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33 characteristics were compared between the two groups with means or medians for
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36 continuous variables and proportions for categorical variables, using Chi-square tests
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39 for categorical variables and a Student's t-test for continuous variables.
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43 To explore the influence of hospital-related factors on temporal improvement of CSC
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46 capabilities, multiple logistic regression models were used. To assess selection bias, we
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49 compared hospital characteristics between consecutively participating hospitals with the
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52 others. All analyses were performed using the JMP Statistical Version 12 Software
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55 (SAS Institute Inc., Cary, NC, USA). P values of < 0.05 were considered statistically
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60 significant.

Ethics approval

The study was approved by the Kyushu University Institutional Review Board, which waived the requirement for individual informed consent.

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 1a. The median (interquartile range) of the CSC scores was 14 (11-18), 17 (13-19), and 17 (12-20.3), for each year, respectively (Table 1a).

Among consecutively participating hospitals, there was an increase in implementation rates of the 14 items, and the CSC scores were (median, interquartile range): 16 (13-19), 18 (14-20), 19 (15-21), for 2010, 2014, and 2018, respectively (p for trend <0.001) (Table 1b). A marked increase ($\geq 20\%$) 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).

In addition, a moderate increase ($\leq 20\%$) was noted in eight items: 24/7 availability of diffusion-weighted magnetic resonance imaging, digital and CT angiography, carotid

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7 ultrasound, coiling of an intracranial aneurysm, and implementation of stroke registry.
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10 In contrast, there was a marked decrease ($\leq 20\%$) in community education.
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14 **Geographical differences in CSC capabilities between 2010 and 2018**

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16 Among the seven items with significant geographical differences in 2010, all items in
17 the personal component still showed a gap, despite overall improvement at all locations
18 in 2018 (Table 2). In contrast, geographical differences in all infrastructure items
19 diminished with overall improvement and a marked improvement in the McEA in 2018.
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26 Over the study period, geographical differences emerged in intra-arterial reperfusion
27 therapy and the number of specialists in physical medicine/rehabilitation. The remaining
28 item, coiling of intracranial aneurysms, showed no changes.
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35 **Influence of hospital characteristics on change in CSC capabilities**

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37 Among consecutively participating hospitals, 23 were excluded due to missing data.
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39 Temporal improvement of CSC capabilities between 2010 and 2018 was noted in 198
40 hospitals (66.0%). As for hospital characteristics, there were significant differences in
41 bed number ($p=0.016$) and CSC score in 2010 ($p=0.032$) between the two groups on
42 univariable analysis (Table 3).
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50 In the logistic regression analyses, the following variables had an association with
51 temporal improvement of CSC capabilities (Table 4): a lower baseline CSC score (odds
52 ratio 0.82 [95% Confidence Interval 0.75-0.9]), bed volume ≥ 500 (3.90, [1.17–13.0]),
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6 and moderate (7-9) number of stroke physicians (2.63, [1.10-6.27]). In contrast,
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10 geographical location, academic status, DPC-based payment system, and case volume
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13 of stroke did not show a significant association.
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17 **Selection bias**

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20 The response rates in 2010, 2014, and 2018 surveys were 55.0%, 39.7%, and 49.9%,
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22 respectively. There were significant differences in the hospital characteristics between
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24 hospitals that consecutively participated in all three surveys and the others
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26 (supplementary table 1). Consecutively participating hospitals were more likely to be
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28 MEA-central, academic, have a larger number of hospital beds, higher annual stroke
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30 admission rate, and more stroke physicians.
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36 **DISCUSSION**

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38 We found an overall improvement in CSC capabilities between 2010 and 2018, and
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40 different trends in geographical disparities based on the component of items. Hospitals
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42 with a higher number of hospital beds, intermediate number of stroke physicians, and a
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44 lower baseline CSC score had a higher likelihood of improving their CSC capabilities.
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50 **Temporal Changes to CSC capabilities**

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52 In addition to a significant increase in CSC capabilities, there was a marked increase in
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54 implementation of the items, mainly related to endovascular treatment and
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56 multidisciplinary care. Of note, we previously showed that interventional 24/7 coverage
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5 and the presence of physical medicine/rehabilitation specialists were associated with
6 reduced in-hospital mortality for those with subarachnoid hemorrhage, whereas
7 availability of neurologists and stroke units were associated with reduced in-hospital
8 mortality and better functional outcomes, respectively, for those with ischemic stroke.¹¹
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15 These findings are consistent with prior studies, which showed admission to a stroke
16 unit with organized stroke care is associated with better quality of care and outcomes in
17 those who experience an acute stroke.^{12 3} The use of mechanical thrombectomy for
18 large vessel acute ischemic stroke (AIS) has been rapidly increasing, but only 3.3% out
19 of 15.1% potentially eligible AIS patients received it in 2016.¹³ Improvement of CSC
20 capabilities, especially related to endovascular treatment and multidisciplinary care
21 should contribute to improved quality of care and outcomes in patients with acute
22 stroke.
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33 Decreased implementation of community education may be explained by limited
34 availability of stroke physicians for this purpose due to increased burden of stroke care
35 (e.g. emergent endovascular call).¹⁴ Stroke educational campaigns have the potential to
36 improve knowledge and awareness, but public campaigns are usually expensive and
37 short-lived and may not achieve any significant improvement.¹⁵
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47 **Diminished and emerging geographical disparity**

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49 Determining rural/urban differences in CSC capabilities may help in the development
50 of targeted interventions to improve stroke care and outcomes in rural areas. We found
51 different trends in implementation of the items between personnel and infrastructure
52 components. Rural areas are associated with reduced access to optimal stroke care and a
53 lower use of acute stroke intervention.¹⁶ Diminished disparities of implementation of
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5 stroke units in this study might result in a higher use of rt-PA infusion in rural areas.¹⁷
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8 Emerging disparities in implementation of intraarterial reperfusion therapy deserves
9 some attention. Since the evidence regarding acute endovascular reperfusion therapy
10 efficacy was established in 2015,¹⁸ relocation of relevant specialists might have
11 occurred from rural to urban areas to meet urgent needs for more widespread use. In
12 addition, a high prevalence of neurointerventional physician burnout may require
13 centralization of acute endovascular reperfusion treatment.¹⁹
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24 **Influence of hospital-related factors on improvement of CSC capabilities**

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26 Our study showed the impact of specific hospital-related factors on improvement of
27 CSC capabilities, which may be useful to determine which hospitals to target to
28 improve CSC capabilities in what regions. In rural areas, where medical resources are
29 limited, centralization of acute stroke care in large hospitals may be needed. It is unclear
30 why the highest quartile of physician volumes was not a significant factor for
31 improvement of CSC capabilities; however, the answer may lie in the presence of a
32 ceiling effect for further improvement.
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45 **Limitations**

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47 There are several limitations to this study. First, this study may have included biased
48 information. Hospitals actively working to improve stroke care are more likely to
49 respond to the questionnaire. Second, the CSC score was a significant composite
50 measure to influence in-hospital mortality of acute stroke, but little information was
51 established on the influence of specific items. Third, we did not determine the influence
52 of unmeasured confounders. Further research is required to examine the influence of
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5 CSC capability improvement on outcomes of patients who experience ischemic and
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7 hemorrhagic stroke.
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10 11 12 **Conclusions**

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14 The CSC capabilities in Japan improved between 2010 and 2018, especially related to
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16 endovascular treatment and multidisciplinary care. Hospital characteristics may be
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18 considered to further improve systems of stroke care in light of limited medical
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20 resources in a defined area.
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28 **Patient consent for publication**

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30 Not required
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33 **Data availability statement**

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35 We have documented the data, methods, and materials used to conduct the
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37 research in this report. The individual patient data are not publicly available
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39 because of the memorandum signed by the director of the participating
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41 hospitals and the principal investigator of the J-ASPECT Study group.
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45 **Authors and contributors**

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47 A Kurogi and KI drafted the manuscript. AN, KN, A Kada, DO, AH and KI were
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49 involved in study concept, design and obtaining funding. A Kada , DO, AH, KO, YS,
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51 TK, KA and KI were involved in analysis and of data. KO, YS, TK and KI were
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53 involved in acquisition of data. All authors reviewed the study report, made comments
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55 or suggestions on the manuscript drafts, and approved the final version.
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Declaration of Conflicting Interests

The Authors declare that there is no conflict of interest related to the submitted work.

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Table 1.

(a)		(b)						
Components	Items	All participating hospitals			Consecutively participating hospitals			
		2010 (n=749)	2014 (n=532)	2018 (n=786)	2010 (n=323)	2014 (n=323)	2018 (n=323)	P value
Personnel	Neurologists	358 (47.8)	283 (53.2)	452 (57.5)	176 (54.5)	177 (54.8)	210 (65.0)	0.009
	Neurosurgeons	694 (92.7)	515 (96.8)	754 (95.9)	314 (97.2)	317 (98.1)	317 (98.1)	0.645
	Endovascular physicians	272 (36.3)	280 (52.6)	428 (54.4)	146 (45.2)	196 (60.7)	211 (65.3)	<0.001
	Emergency medicine	162 (21.6)	207 (38.9)	427 (54.3)	96 (29.7)	146 (45.2)	205 (63.5)	<0.001
	Physical medicine and rehabilitation	113 (15.1)	143 (26.9)	313 (39.8)	61 (18.9)	95 (29.4)	137 (42.4)	<0.001
	Rehabilitation therapy	742 (99.1)	529 (99.4)	779 (99.1)	321 (99.4)	321 (99.4)	321 (99.4)	1
	Stroke rehabilitation nurses	102 (13.6)	157 (29.5)	285 (36.2)	48 (14.9)	116 (35.9)	146 (45.2)	<0.001

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4	Diagnostic	CT	742 (99.1)	527 (99.1)	763 (97.1)	322 (99.7)	322 (99.7)	322 (99.7)	1
5		MRI with diffusion	647 (86.4)	504 (94.7)	732 (93.1)	291 (90.1)	311 (96.3)	314 (97.2)	<0.001
6		Digital cerebral							
7		angiography	602 (80.3)	476 (89.4)	638 (81.2)	288 (89.2)	305 (94.4)	299 (92.6)	0.043
8		CT angiography	627 (83.7)	492 (92.5)	701 (89.2)	289 (89.5)	305 (94.4)	309 (95.7)	0.004
9		Carotid duplex							
10		ultrasound	257 (34.3)	219 (41.2)	343 (43.6)	126 (39.0)	153 (47.4)	169 (52.3)	0.003
11		Transcranial Doppler							
12		ultrasound	121 (16.2)	123 (23.1)	162 (20.6)	70 (21.7)	87 (26.9)	95 (29.4)	0.073
13	Specific	Carotid							
14	Expertise	endarterectomy	603 (80.5)	458 (86.1)	613 (78.0)	292 (90.4)	288 (89.2)	284 (87.9)	0.599
15		Clipping of							
16		intracranial	685 (91.5)	504 (94.7)	706 (89.8)	314 (97.2)	315 (97.5)	314 (97.2)	0.961
17		aneurysm							
18		Hematoma							
19		removal/draining	689 (92.0)	505 (95.0)	718 (91.3)	315 (97.5)	315 (97.5)	314 (97.2)	0.96
20		Coiling of	3360 (48.1)	332 (62.4)	448 (57.0)	192 (59.4)	223 (69.0)	223 (69.0)	0.001

	intracranial							
	aneurysm							
	Intra-arterial							
	reperfusion therapy	498 (66.5)	398 (74.8)	510 (64.9)	245 (75.9)	261 (80.8)	247 (76.5)	0.257
Infrastructure	Stroke unit	132 (17.6)	202 (38.0)	342 (43.5)	74 (22.9)	136 (42.1)	171 (52.9)	<0.001
	Intensive care unit	445 (59.4)	362 (68.0)	467 (59.4)	214 (66.3)	224 (69.4)	220 (68.1)	0.698
	Operating room							
	staffed 24/7	451 (60.2)	339 (63.7)	487 (62.0)	230 (71.2)	239 (74.0)	243 (75.2)	0.495
	Interventional							
	services coverage	279 (37.3)	317 (59.6)	452 (57.5)	147 (45.5)	218 (67.5)	219 (67.8)	<0.001
	24/7							
	Stroke registry	235 (31.4)	260 (48.9)	349 (44.4)	133 (41.2)	172 (53.3)	164 (50.8)	0.005
Education	Community							
	education	369 (49.3)	144 (27.1)	204 (26.0)	188 (58.2)	91 (28.2)	98 (30.3)	<0.001
	Professional							
	education	436 (58.2)	326 (61.3)	429 (54.6)	207 (64.1)	208 (64.4)	184 (57.0)	0.089
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	Total CSC score							

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5	median, (IQR)	14 (11, 18)	17 (13, 19)	17 (12, 20.3)	16 (13, 19)	18 (14, 20)	19 (15, 21)	<0.001
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Table 2.

		a) 2010				b) 2018		
		MEA central	MEA	McEA	P value	MEA central	MEA	McEA
		(n=186)	outlying (n=79)	(n=35)		(n=186)	outlying (n=79)	(n=35)
Personnel	Neurologists	115 (61.8)	44 (55.7)	10 (28.6)	0.001	133(71.5)	55(69.6)	14 (40.0)
	Neurosurgeons	181 (97.3)	77 (97.5)	34 (97.1)	0.995	183 (98.4)	78 (98.7)	34 (97.1)
	Endovascular physicians	101 (54.3)	31 (39.2)	8 (22.9)	<0.001	136 (73.1)	49 (62.0)	14 (40.0)
	Emergency medicine	57 (30.7)	25 (31.7)	7 (20.0)	0.406	122 (65.6)	54 (68.4)	16 (45.7)
	Physical medicine and rehabilitation	36 (19.4)	16 (20.3)	5 (14.3)	0.740	83 (44.6)	42 (53.2)	3 (8.6)
	Rehabilitation therapy	185 (99.5)	78 (98.7)	35 (100)	0.701	185 (99.5)	78 (98.7)	35 (100)
	Stroke	33 (17.8)	9 (11.4)	1 (2.9)	0.049	90 (48.4)	41 (51.9)	9 (25.7)

	rehabilitation nurses							
	CT	185 (99.5)	79 (100.0)	35 (100.0)	0.735	185 (100)	79 (100)	35 (100)
	MRI with diffusion	167 (89.8)	69 (87.3)	33 (94.3)	0.530	179 (96.2)	78 (98.7)	35 (100)
	Digital cerebral angiography	165 (88.7)	70 (88.6)	34 (97.1)	0.303	168 (90.3)	76 (96.2)	33 (94.3)
	CT angiography	163 (87.6)	72 (91.1)	32 (91.4)	0.627	176 (94.6)	77 (97.5)	34 (97.1)
	Carotid duplex ultrasound	71 (38.1)	30 (38.0)	14 (40.0)	0.977	95 (51.1)	48 (60.8)	15 (42.9)
	TCD	43 (23.1)	18 (22.8)	3 (8.6)	0.146	54 (29.0)	29 (36.7)	5 (14.3)
	Carotid endarterectomy	173 (93.0)	68 (86.1)	32 (91.4)	0.196	166 (89.3)	71 (89.9)	28 (80)
	Clipping of intracranial aneurysm	183 (98.4)	75 (94.9)	34 (97.1)	0.280	181 (97.3)	77 (97.5)	34 (97.1)
	Hematoma removal/draining	183 (98.4)	76 (96.2)	34 (97.1)	0.546	182 (97.9)	77 (97.5)	35 (94.3)

	Coiling of intracranial aneurysm	119 (64.0)	46 (58.2)	13 (37.1)	0.012	143 (76.9)	49 (62.0)	17 (48.6)
	Intra-arterial reperfusion therapy	142 (76.3)	58 (73.4)	27 (77.1)	0.859	153 (82.3)	57 (72.2)	22 (62.9)
Infrastructure	Stroke unit	50 (26.9)	17 (21.5)	2 (5.7)	0.023	106 (57.0)	44 (55.7)	13 (37.1)
	Intensive care unit	123 (66.1)	54 (68.4)	21 (60.0)	0.685	134 (72.0)	54 (68.4)	18 (51.4)
	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)
	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)
	Stroke registry	81 (43.6)	31 (29.1)	15 (42.9)	0.808	93 (50.0)	47 (59.5)	15 (42.9)
Education	Community education	110 (59.1)	53 (67.1)	17 (48.6)	0.164	55 (29.6)	28 (35.4)	8 (22.9)

	Professional education	125 (67.2)	53 (67.1)	17 (48.6)	0.095	105 (56.5)	47 (59.5)	17 (48.6)
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*MEA metropolitan, McEA
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Table 3.

Hospital-related factors in All Hsps.		Improvement Hsps. (n=198)	No improvement Hsps. (n=102)	p value [#]
2010	(n=300)			
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Hospital 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, 19)	16 (13, 18)	17 (13, 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 physicians				0.139
median (IQR)	6 (3, 9)	6 (3.8, 9)	5 (3, 9.3)	
0-3	82 (27.3)	49 (24.8)	33 (32.4)	
4-6	68 (22.7)	43 (21.7)	25 (24.5)	
7-9	80 (26.7)	61 (30.8)	19 (18.6)	

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4 ≥ 10 70 (23.3) 45 (22.7) 25 (24.5)
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7 *DPC: Diagnostic Procedure Combination, Hsp: hospital, # p value: Improvement vs. No improvement hospitals, MEA: metropolitan,
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9 McEA: micropolitan
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Table 4.

Hospital-related factors in 2010	Odds	95%CI	P value
Hospital locations			
MEA central	1.00		
MEA outlying	1.42	0.76-2.65	0.269
McEA	0.82	0.36-1.86	0.632
CSC score in 2010	0.82	0.75-0.90	<0.001
Academic hospital	1.37	0.54-3.48	0.506
DPC hospital	0.77	0.41-1.42	0.397
Number of beds			
1-99	1.00		
100-299	1.16	0.37-3.66	0.794
300-499	1.68	0.56-5.10	0.358

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4	≥ 500	3.90	1.17-13.00	0.027
5				
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7				
8	Annual stroke case volume			
9				
10	1-99	1.00		
11				
12	100-199	1.62	0.64-4.07	0.305
13				
14	200-299	2.41	0.89-6.49	0.083
15				
16	≥ 300	2.74	0.99-7.54	0.051
17				
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20	Number of stroke physicians			
21				
22	0-3	1.00		
23				
24	4-6	1.77	0.81-3.88	0.153
25				
26	7-9	2.63	1.10-6.27	0.030
27				
28	≥ 10	1.58	0.57-4.38	0.380
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Supplemental material

eTable 1. Univariable analysis of association between consecutively participating hospitals in all three surveys and the others

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eTable 1

	All Hsps. in 2010 (n=749)	Consecutively participating Hsps. (n=323)	Other Hsps. (n=426)	p value
Hospital location				<0.001
MEA central	381 (50.9)	193 (59.8)	188 (44.1)	
MEA outlying	239 (31.9)	83 (25.7)	156(36.6)	
McEA	102 (13.6)	38 (11.8)	64 (15.0)	
Unclassified	27 (3.6)	9 (2.8)	18 (4.2)	
CSC score at 2010				
median (IQR)	14 (11, 18)	16 (13, 19)	13 (10, 17)	<0.001
Academic hospital	90 (12.1)	61 (18.9)	29 (6.8)	<0.001
DPC hospital	553 (73.8)	237 (73.4)	316 (74.2)	0.804
Number of beds				<0.001
-99	50 (6.7)	19 (5.9)	31 (7.3)	
100-299	232 (31.0)	75 (23.2)	157 (36.9)	
300-499	260 (34.7)	105 (32.5)	155 (36.4)	
≥500	207 (27.6)	124 (38.4)	83 (19.5)	
Annual stroke volume				<0.001
-99	129 (17.2)	36 (11.2)	93 (21.8)	

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5	100-199	199 (26.5)	76 (23.5)	123 (28.9)	
6	200-299	155 (20.7)	70 (21.7)	85 (20.0)	
7					
8	≥300	228 (30.4)	127 (39.3)	101 (23.7)	
9					
10	N/A	38 (5.1)	14 (4.3)	24 (5.6)	
11	Stroke physician				<0.001
12					
13	median (IQR)	4 (3, 7)	5 (3, 9)	4 (2, 6)	
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Temporal trends and geographical disparities in comprehensive stroke centre capabilities in Japan from 2010 to 2018

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6 Temporal trends and geographical disparities in comprehensive stroke centre
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8 capabilities in Japan from 2010 to 2018
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17 Koichi Arimura¹, and Koji Iihara¹, on behalf of the J-ASPECT Study Collaborators
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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 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 in 2010, 532 in 2014 and 786 in 2018 hospitals that participate in the J-ASPECT study.

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.

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7 Results: Among the 323 hospitals that responded to all surveys, the
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10 implementation of 14 recommended items increased. The CSC score (median,
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13 interquartile range) was 16 (13-19), 18 (14-20), 19 (15-21), for 2010, 2014, and
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16 2018, respectively ($p < 0.001$). There was a $\geq 20\%$ increase in six items (e.g.
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19 endovascular physicians, stroke unit, and interventional coverage 24/7), and a \leq
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23 20% decrease in community education. A lower baseline CSC score (odds ratio
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26 0.82, [95% confidence interval] 0.75-0.9), the number of beds ≥ 500 (3.9 [1.2–
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29 13.0]), and the number of stroke physicians (7-9) (2.6 [1.1-6.3]) was associated
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33 with improved CSC capabilities, independent of geographical location.

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36 Conclusions: There was a significant improvement in CSC capabilities between
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39 2010 and 2018, which was mainly related to the availability of endovascular
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42 treatment and multidisciplinary care. Our findings may be useful to determine
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45 which hospitals should be targeted to improve CSC capabilities in a defined area.
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51 Strengths and limitations of this study:

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54 • A large-scale, representative hospitals of Japan provided data on temporal
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56 trends in the CSC capabilities for this cross-sectional study.
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6 • Hospitals actively working to improve stroke care are more likely to respond
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8 to the questionnaire, which may lead to information bias.
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11 • The CSC score was a significant composite measure to influence in-hospital
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13 mortality of acute stroke, but little information was established on the
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15 influence of specific items.
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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} number of physicians, and geographical locations of the facility⁷. Progressive rural-urban disparities in acute stroke care have been reported in the United States,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

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6 registry. We demonstrated significant geographical differences in CSC
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9 capabilities in 2010,⁹ and that CSC capabilities of a facility are associated with
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11 reduced in-hospital mortality from acute stroke.¹⁰ Thus continuous monitoring
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13 of the CSC capabilities may be clinically meaningful to improve stroke
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15 outcomes.^{10, 11} Since 2010, we have conducted nationwide benchmark analyses
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17 to allow participating hospitals to facilitate improvement of stroke care.
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19 However, it remains unclear whether there are improving trends in the CSC
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21 capabilities, or how hospital-related factors determine quality improvement.
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36 AIMS

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38 We aimed to examine whether CSC capabilities in Japan changed from 2010 to
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40 2018 and whether any recorded changes were influenced by hospital
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42 characteristics.
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53 METHODS

54 Institutional survey of CSC capabilities

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7 This cross-sectional survey used the DPC discharge database from participating
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10 institutions in the J-ASPECT study. Participation in the J-ASPECT study was
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13 voluntary. Of the 1369 training institutions certified by the Japan Neurosurgical
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16 Society, the Japanese Society of Neurology, and the Japan Stroke Society, 621
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19 agreed to participate in this study. The J-ASPECT study group analysed the
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23 Diagnosis Procedure Combination (DPC) database to gain new clinical insights
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26 on ischaemic and haemorrhagic stroke, an approach we applied again for this
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29 cross-sectional survey. In this study, we sent out questionnaires to the training
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33 institutions of all three societies in 2010, 2014, and 2018 to assess CSC
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36 capabilities. The CSC capabilities of each facility were assessed with a validated
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39 scoring system (CSC score), using 25 items recommended by the Brain Attack
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46 All items were classified into five categories: personnel, diagnostic, specific
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49 expertise, infrastructure, and education. A score of 1 was assigned for meeting
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53 each item, yielding a total CSC score of up to 25. Content, constructs, and
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56 predictive validity of this scoring system have been previously reported.^{12, 13}
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Other hospital characteristics

Hospital characteristics including number of beds, annual stroke hospitalisations, stroke physicians, academic status, adoption of the Diagnosis Procedure Combination (DPC)-based payment system⁹, 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. 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

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6 on the change in CSC capabilities, we divided the hospitals into those with or
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10 without a temporal improvement of CSC score (≥ 1 -point increase between 2010
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13 and 2018). The increase of “One point” was set based on our previous report on
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16 the CSC score.¹¹ In that study, we showed that even a small preceding
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19 improvement of the CSC score was associated with reduced in-hospital
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22 mortality, reduced poor outcomes, and higher use of acute reperfusion therapy
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25 in AIS patients; our findings also suggested the difficulty in improving the CSC
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28 score in a relatively short time period.
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33 We used a chi-squared test to detect differences between consecutively participating
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36 hospitals and other hospitals in the number of each hospital item. We did not perform
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39 multiple tests. Wilcoxon rank sum test was used to compare total CSC scores between
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42 consecutively participating hospitals and other hospitals.
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46 To explore the influence of hospital-related factors on temporal improvement of
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49 CSC capabilities, multiple logistic regression models were used. To assess
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52 selection bias, we compared hospital characteristics between consecutively
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55 participating hospitals with the others. We also examined the relationship between
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6 “number of physicians” and “hospital size” and the relationship between “number of
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10 physicians” and “CSC score” using chi-squared tests. All analyses were performed
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13 using the JMP Statistical Version 12 Software (SAS Institute Inc., Cary, NC,
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16 USA). P values of <0.05 were considered statistically significant.
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23 **Patient and public involvement**

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26 Data for this study are based on information collected by the J-ASPECT study.
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30 Patients and the public were not involved in the development of this study.
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36 **RESULTS**

37 38 39 **Trends in the CSC capabilities from 2010 to 2018**

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42 A total of 749, 532, and 786 hospitals responded to the survey in 2010, 2014, and
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45 2018, respectively. The implementation rates of each item are shown in Table 1.
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50 The median (interquartile range) of the CSC scores was 14 (11-18), 17 (13-19),
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53 and 17 (12-20.3), for each year, respectively (Table 1).
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56 Among consecutively participating hospitals, there was an increase in
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7 implementation rates of the 14 items, and the CSC scores were (median,
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10 interquartile range): 16 (13-19), 18 (14-20), 19 (15-21), for 2010, 2014, and 2018,
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13 respectively ($p < 0.001$) (Table 1). A marked increase ($\geq 20\%$) was noted in six
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16 items related to endovascular treatment (endovascular physicians and
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19 interventional coverage 24/7) and multidisciplinary care (stroke unit, specialists
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22 of emergency medicine and physical medicine/rehabilitation, and stroke
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27 rehabilitation nurses).

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30 In addition, a moderate increase ($\leq 20\%$) was noted in eight items: 24/7
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33 availability of diffusion-weighted magnetic resonance imaging, digital and CT
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36 angiography, carotid ultrasound, coiling of an intracranial aneurysm, and
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39 implementation of stroke registry. In contrast, there was a marked decrease
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43 ($\leq 20\%$) in community education.
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50 **Geographical differences in CSC capabilities between 2010 and 2018**

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53 Among the seven items with significant geographical differences in 2010, all
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56 items in the personal component still showed a gap, despite overall
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6 improvement at all locations in 2018 (Table 2). In contrast, geographical
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9 differences in all infrastructure items diminished with overall improvement
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12 and a marked improvement in the McEA in 2018.
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16 Over the study period, geographical differences emerged in intra-arterial
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19 reperfusion therapy and the number of specialists in physical
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22 medicine/rehabilitation. The remaining item, coiling of intracranial aneurysms,
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25 showed no changes.
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33 **Influence of hospital characteristics on change in CSC capabilities**

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36 Among consecutively participating hospitals, 23 were excluded due to missing
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39 data. Temporal improvement of CSC capabilities between 2010 and 2018 was
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42 noted in 198 hospitals (66.0%). As for hospital characteristics, there were weakly
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45 significant differences in bed number ($p=0.016$) and CSC score in 2010 ($p=0.032$)
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48 between the two groups on univariable analysis (Table 3).
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53 In the logistic regression analyses, the following variables had an association
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56 with temporal improvement of CSC capabilities (Table 4): a lower baseline CSC
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6 score (odds ratio 0.82 [95% confidence interval 0.75-0.9]), bed volume ≥ 500 (3.90,
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9 [1.17–13.0]), and moderate (7-9) number of stroke physicians (2.63, [1.10-6.27]).

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13 In contrast, geographical location, academic status, DPC-based payment system,
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16 and case volume of stroke did not show a significant association. We also
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19 performed the logistic regression analysis adjusting tertile, instead of quartile,
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22 of stroke physician volume in addition to the other adjusting factors. Except for
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25 Q3 of stroke physician volume, we found very similar results (Supplementary
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28 Table 1). Additionally, there was a significant relationship between hospital size and
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31 number of physicians ($P < 0.001$), and between CSC score and number of
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34 physicians ($P < 0.001$), and between CSC score and number of
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37 physicians ($P < 0.001$).

38 39 40 41 42 43 **Selection bias**

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46 The response rates of the 2010, 2014, and 2018 surveys were 55.0%, 39.7%, and
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49 49.9%, respectively. We found that a selection bias did exist; in fact, the total
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52 CSC scores and most of the implementation rates of each item were
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55 significantly higher for the consecutively participating hospitals than for the
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6 others in all three surveys (Table 1). Consecutively participating hospitals were
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10 more likely to be MEA-central, academic, have a larger number of hospital beds,
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13 higher annual stroke admission rate, and more stroke physicians
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16 (Supplementary Table 2).
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27 DISCUSSION

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30 We found an overall improvement in CSC capabilities between 2010 and 2018,
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33 and different trends in geographical disparities for different items. Hospitals
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36 with a higher number of hospital beds, intermediate number of stroke
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39 physicians, and a lower baseline CSC score had a higher likelihood of
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43 improving their CSC capabilities.
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50 **Temporal Changes to CSC capabilities**

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53 In addition to a significant increase in CSC capabilities, there was a marked
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56 increase in implementation of the items, mainly related to endovascular
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7 treatment and multidisciplinary care. Of note, we previously showed that
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10 interventional 24/7 coverage and the presence of physical
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13 medicine/rehabilitation specialists were associated with reduced in-hospital
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16 mortality for patients with subarachnoid haemorrhage, whereas availability of
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19 neurologists and stroke units were associated with reduced in-hospital
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22 mortality and better functional outcomes, respectively, for those with ischaemic
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26 stroke.¹³
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30 These findings are consistent with those of prior studies, which have shown
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33 that admission to a stroke unit with organised stroke care is associated with
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36 better quality of care and outcomes in those who experience an acute stroke.^{14 3}
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40 Although the use of mechanical thrombectomy for large vessel acute ischaemic
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43 stroke (AIS) has been rapidly increasing, only 3.3% of 15.1% potentially eligible
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46 AIS patients received it in 2016.¹⁵ Improvement of CSC capabilities, especially
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49 related to endovascular treatment and multidisciplinary care, should contribute
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53 to improved quality of care and outcomes in patients with acute stroke.
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56 The decreased implementation of community education observed in this study
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7 may be explained by the limited number of stroke physicians available for this
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10 purpose due to an increased burden of stroke care (e.g. emergent endovascular
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13 calls).¹⁶ Stroke educational campaigns have the potential to improve
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16 knowledge and awareness, but public campaigns are usually expensive and
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19 short-lived and may not achieve any significant improvement.¹⁷
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26 **Diminished and emerging geographical disparities**

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30 Determining rural/urban differences in CSC capabilities may support the
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33 development of targeted interventions to improve stroke care and outcomes in
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36 rural areas. We found differing trends in implementation of the items according
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39 to personnel and infrastructure components. Rural areas are associated with
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42 reduced access to optimal stroke care and a lower use of acute stroke
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45 intervention.¹⁸ The diminished disparities in implementation of stroke units in
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48 this study might result in a higher use of rt-PA infusion in rural areas.¹⁹
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54 The emerging disparities in implementation of intraarterial reperfusion
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57 therapy deserve some attention. Since the evidence regarding the efficacy of
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6 acute endovascular reperfusion therapy was established in 2015,²⁰ relocation of
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10 relevant specialists might have occurred from rural to urban areas to meet the
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13 urgent need created by more widespread use. In addition, a high prevalence of
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16 neurointerventional physician burnout may require centralisation of acute
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19 endovascular reperfusion treatment.²¹
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26 **Influence of hospital-related factors on improvement of CSC capabilities**

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29 Our study showed the impact of specific hospital-related factors on
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32 improvement of CSC capabilities, which may be useful to determine which
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35 hospitals should be targeted to improve CSC capabilities, and in what regions.
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40 In rural areas, where medical resources are limited, centralisation of acute
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43 stroke care in large hospitals may be needed. We also found a significant
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46 relationship between CSC score and number of physicians. This means that, in
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49 2010, institutions with more physicians tended to have higher baseline CSC scores. The
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52 reason that a physician volume of more than 10 did not affect the improvement of the
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55 CSC score may be explained by the ceiling effect of a high baseline CSC score in 2010.
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Limitations

There are several limitations of this study. First, this findings may have included biased information. Hospitals actively working to improve stroke care would be more likely to respond to the questionnaire. 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 PSCs (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

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7 required to examine the effect of 2014 data on the analysis.
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10 **Conclusions**

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13 The CSC capabilities in Japan improved between 2010 and 2018, especially
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16 related to endovascular treatment and multidisciplinary care. Our findings may
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19 be useful to determine which hospitals should be targeted to improve CSC capabilities
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23 in a defined area.
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53 Japan Society for the Promotion of Science.
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Competing interests statement

None declared.

Ethics approval

The study was approved by the Kyushu University Institutional Review Board, which waived the requirement for individual informed consent (No. 28-335)

Data availability statement

We have documented the data, methods, and materials used to conduct the research in this report. The individual patient data are not publicly available because of the memorandum signed by the director of the participating hospitals and the principal investigator of the J-ASPECT Study group.

Authors and contributors

A Kurogi and KI drafted the manuscript. AN, KN, A Kada, DO, AH and KI were involved in study concept, design and obtaining funding. A Kada , DO,

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6 AH, KO, YS, TK, KA and KI were involved in analysis and of data. KO, YS, TK
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10 and KI were involved in acquisition of data. All authors reviewed the study
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13 report, made comments or suggestions on the manuscript drafts, and approved
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16 the final version.
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35 Collaborators are listed in Supplemental Appendix 1.
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43 **Patient consent for publication**

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

Components	Items	2010				2014		
		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)	C
Personnel	Neurologists	358 (47.8)	176 (54.5)	182 (42.7)	0.001	283 (53.2)	177 (54.8)	10
	Neurosurgeons	694 (92.7)	314 (97.2)	380 (89.2)	<0.001	515 (96.8)	317 (98.1)	19
	Endovascular physicians	272 (36.3)	146 (45.2)	126 (29.6)	<0.001	280 (52.6)	196 (60.7)	84
	Emergency medicine	162 (21.6)	96 (29.7)	66 (15.5)	<0.001	207 (38.9)	146 (45.2)	61

	Physical medicine and rehabilitation	113 (15.1)	61 (18.9)	52 (12.2)	0.011	143 (26.9)	95 (29.4)	48
	Rehabilitation therapy	742 (99.1)	321 (99.4)	421 (98.8)	0.435	529 (99.4)	321 (99.4)	20
	Stroke rehabilitation nurses	102 (13.6)	48 (14.9)	54 (12.7)	0.388	157 (29.5)	116 (35.9)	41
Diagnostic	CT	742 (99.1)	322 (99.7)	420 (98.6)	0.122	527 (99.1)	322 (99.7)	20
	MRI with diffusion	647 (86.4)	291 (90.1)	356 (83.6)	0.01	504 (94.7)	311 (96.3)	19
	Digital cerebral angiography	602 (80.3)	288 (89.2)	314 (73.7)	<0.001	476 (89.4)	305 (94.4)	17
	CT angiography	627 (83.7)	289 (89.5)	338 (79.3)	<0.001	492 (92.5)	305 (94.4)	18
	Carotid duplex ultrasound	257 (34.3)	126 (39.0)	131 (30.8)	0.018	219 (41.2)	153 (47.4)	66

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5		TCD	121 (16.2)	70 (21.7)	51 (12.0)	<0.001	123 (23.1)	87 (26.9)	36
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8									
9	Specific								
10		Carotid endarterectomy	603 (80.5)	292 (90.4)	311 (73.0)	<0.001	458 (86.1)	288 (89.2)	17
11									
12	Expertise								
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15		Clipping of intracranial							
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17			685 (91.5)	314 (97.2)	371 (87.1)	<0.001	504 (94.7)	315 (97.5)	18
18		aneurysm							
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22		Hematoma							
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24			689 (92.0)	315 (97.5)	374 (87.8)	<0.001	505 (95.0)	315 (97.5)	19
25		removal/draining							
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29		Coiling of intracranial							
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31			360 (48.1)	192 (59.4)	168 (39.4)	<0.001	332 (62.4)	223 (69.0)	10
32		aneurysm							
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35		Intra-arterial reperfusion	498 (66.5)	245 (75.9)	253 (59.4)	<0.001	398 (74.8)	261 (80.8)	13
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	therapy							
Infrastructure	Stroke unit	132 (17.6)	74 (22.9)	58 (13.6)	<0.001	202 (38.0)	136 (42.1)	66
	Intensive care unit	445 (59.4)	214 (66.3)	231 (54.2)	<0.001	362 (68.0)	224 (69.4)	13
	Operating room staffed 24/7	451 (60.2)	230 (71.2)	221 (51.9)	<0.001	339 (63.7)	239 (74.0)	10
	Interventional services coverage 24/7	279 (37.3)	147 (45.5)	132 (31.0)	<0.001	317 (59.6)	218 (67.5)	99
	Stroke registry	235 (31.4)	133 (41.2)	102 (23.9)	<0.001	260 (48.9)	172 (53.3)	88
Education	Community education	369 (49.3)	188 (58.2)	181 (42.5)	<0.001	144 (27.1)	91 (28.2)	53
	Professional education	436 (58.2)	207 (64.1)	229 (53.8)	0.005	326 (61.3)	208 (64.4)	11
Total CSC score								

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median, (IQR)	14 (11, 18)	16 (13, 19)	13 (10, 17)	<0.001	17 (13, 19)	18 (14, 20)	15
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Hsp, hospital; CT, computed tomography; MRI, magnetic resonance imaging; TCD, transcranial Doppler.

For peer review only

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

		a) 2010				b) 2018		
		MEA central	MEA outlying	McEA	P value	MEA central	MEA outlying	McEA
		(n=186)	(n=79)	(n=35)		(n=186)	(n=79)	(n=35)
Personnel	Neurologists	115 (61.8)	44 (55.7)	10 (28.6)	0.001	133(71.5)	55(69.6)	14 (40.0)
	Neurosurgeons	181 (97.3)	77 (97.5)	34 (97.1)	0.995	183 (98.4)	78 (98.7)	34 (97.1)
	Endovascular physicians	101 (54.3)	31 (39.2)	8 (22.9)	<0.001	136 (73.1)	49 (62.0)	14 (40.0)
	Emergency medicine	57 (30.7)	25 (31.7)	7 (20.0)	0.406	122 (65.6)	54 (68.4)	16 (45.7)
	Physical medicine and rehabilitation	36 (19.4)	16 (20.3)	5 (14.3)	0.740	83 (44.6)	42 (53.2)	3 (8.6)
	Rehabilitation therapy	185 (99.5)	78 (98.7)	35 (100)	0.701	185 (99.5)	78 (98.7)	35 (100)

	Stroke rehabilitation nurses	33 (17.8)	9 (11.4)	1 (2.9)	0.049	90 (48.4)	41 (51.9)	9 (25.7)
Diagnostic	CT	185 (99.5)	79 (100.0)	35 (100.0)	0.735	185 (100)	79 (100)	35 (100)
	MRI with diffusion	167 (89.8)	69 (87.3)	33 (94.3)	0.530	179 (96.2)	78 (98.7)	35 (100)
	Digital cerebral angiography	165 (88.7)	70 (88.6)	34 (97.1)	0.303	168 (90.3)	76 (96.2)	33 (94.3)
	CT angiography	163 (87.6)	72 (91.1)	32 (91.4)	0.627	176 (94.6)	77 (97.5)	34 (97.1)
	Carotid duplex ultrasound	71 (38.1)	30 (38.0)	14 (40.0)	0.977	95 (51.1)	48 (60.8)	15 (42.9)
	TCD	43 (23.1)	18 (22.8)	3 (8.6)	0.146	54 (29.0)	29 (36.7)	5 (14.3)
Specific Expertise	Carotid endarterectomy	173 (93.0)	68 (86.1)	32 (91.4)	0.196	166 (89.3)	71 (89.9)	28 (80)
	Clipping of intracranial aneurysm	183 (98.4)	75 (94.9)	34 (97.1)	0.280	181 (97.3)	77 (97.5)	34 (97.1)
	Hematoma removal/draining	183 (98.4)	76 (96.2)	34 (97.1)	0.546	182 (97.9)	77 (97.5)	35 (94.3)
	Coiling of intracranial aneurysm	119 (64.0)	46 (58.2)	13 (37.1)	0.012	143 (76.9)	49 (62.0)	17 (48.6)

	Intra-arterial reperfusion therapy	142 (76.3)	58 (73.4)	27 (77.1)	0.859	153 (82.3)	57 (72.2)	22 (62.9)
Infrastructure	Stroke unit	50 (26.9)	17 (21.5)	2 (5.7)	0.023	106 (57.0)	44 (55.7)	13 (37.1)
	Intensive care unit	123 (66.1)	54 (68.4)	21 (60.0)	0.685	134 (72.0)	54 (68.4)	18 (51.4)
	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)
	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)
	Stroke registry	81 (43.6)	31 (29.1)	15 (42.9)	0.808	93 (50.0)	47 (59.5)	15 (42.9)
Education	Community education	110 (59.1)	53 (67.1)	17 (48.6)	0.164	55 (29.6)	28 (35.4)	8 (22.9)
	Professional education	125 (67.2)	53 (67.1)	17 (48.6)	0.095	105 (56.5)	47 (59.5)	17 (48.6)

*MEA

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

Hospital-related factors in 2010	all participating (n=300)	Consecutively Hsps.	Improvement Hsps. (n=198)	No improvement Hsps. (n=102)	p value [#]
Hospital 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, 19)		16 (13, 18)	17 (13, 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)	

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5	≥500	119 (39.7)	90 (45.5)	29 (28.4)	
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8	Annual stroke case volume				0.915
9	0-99	34 (11.3)	21 (10.6)	13 (12.8)	
10	100-199	73 (24.3)	47 (23.7)	26 (25.5)	
11	200-299	67 (22.3)	45 (22.7)	22 (21.6)	
12	≥300	126 (42.0)	85 (42.9)	41 (40.2)	
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18	Number of stroke physician volume				
19	median (IQR)	6 (3, 9)	6 (3.8, 9)	5 (3, 9.3)	0.139
20					
21	Number of stroke physicians, quartile				
22					
23	Q1 (0-3)	82 (27.3)	49 (24.8)	33 (32.4)	
24	Q2 (4-6)	68 (22.7)	43 (21.7)	25 (24.5)	
25	Q3 (7-9)	80 (26.7)	61 (30.8)	19 (18.6)	
26	Q4 (≥10)	70 (23.3)	45 (22.7)	25 (24.5)	
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32					
33	Number of stroke physicians, tertile				
34	T1 (0-4)	114 (38.0)	72 (36.4)	42 (41.2)	
35	T2 (4-8)	96 (32.0)	63 (31.8)	33 (32.4)	
36	T3 (≥9)	90 (30.0)	63 (31.8)	27 (26.5)	
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7 *DPC: Diagnostic Procedure Combination, Hsp: hospital, # p value: Improvement vs. No improvement hospitals, MEA:
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9 metropolitan, McEA: micropolitan
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Table 4. Multivariable analysis of the impact of hospital characteristics on one-point increases of the CSC score

Hospital-related factors in 2010	Odds	95%CI	P value
Hospital locations			
MEA central	ref.		
MEA outlying	1.42	0.76-2.65	0.269
McEA	0.82	0.36-1.86	0.632
CSC score in 2010	0.82	0.75-0.90	<0.001

Academic hospital	1.37	0.54-3.48	0.506
DPC hospital	0.77	0.41-1.42	0.397
Number of beds			
1-99	ref.		
100-299	1.16	0.37-3.66	0.794
300-499	1.68	0.56-5.10	0.358
≥500	3.9	1.17-13.00	0.027

Annual stroke case volume			
1-99	ref.		
100-199	1.62	0.64-4.07	0.305
200-299	2.41	0.89-6.49	0.083
≥300	2.74	0.99-7.54	0.051
Number of stroke physician volume quartile			
Q1 (0-3)	ref.		
Q2 (4-6)	1.77	0.81-3.88	0.153

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Q3 (7-9)	2.63	1.10-6.27	0.030
Q4 (≥ 10)	1.58	0.57-4.38	0.380

*DPC: Diagnostic Procedure Combination, Hsp: hospital, # p value: Improvement vs. No improvement hospitals, MEA: metropolitan, McEA: micropolitan

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Supplemental material

eTable 1. Multivariable analysis of the impact of the hospital characteristics on one-point increase of the CSC score

eTable 2. Univariable analysis of association between consecutively participating hospitals in all three surveys and the others

Supplemental Appendix 1. List of the J-ASPECT Study Collaborators.

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eTable 1 Multivariable analysis of the impact of the hospital characteristics on one-point increase of the CSC score

Hospital-related factors in 2010	Odds	95%CI	P value
Hospital locations			
MEA central	ref.		
MEA outlying	1.35	0.36-2.48	0.339
McEA	0.78	0.35-1.75	0.549
CSC score in 2010	0.83	0.76-0.91	<0.001
Academic hospital	1.29	0.52-3.24	0.582
DPC hospital	0.72	0.39-1.34	0.302
Number of beds			
1-99	ref.		
100-299	1.1	0.36-3.41	0.868
300-499	1.82	0.60-5.48	0.285
≥500	3.81	1.16-12.54	0.028
Annual stroke case volume			

1-99	ref.		
100-199	1.68	0.67-4.18	0.267
200-299	2.47	0.92-6.61	0.072
≥300	3.17	1.16-8.66	0.024
Number of stroke physicians, tertile			
T1 (0-4)	ref.		
T2 (4-8)	1.12	0.58-2.16	0.745
T3 (≥9)	1.35	0.57-3.21	0.492

eTable 2 Univariable analysis of association between consecutively participating hospitals in all three surveys and the others

	All Hsps. in 2010 (n=749)	Consecutively participating Hsps. (n=323)	Other Hsps. (n=426)	p value
Hospital location				<0.001
MEA central	381 (50.9)	193 (59.8)	188 (44.1)	
MEA outlying	239 (31.9)	83 (25.7)	156(36.6)	
McEA	102 (13.6)	38 (11.8)	64 (15.0)	
Unclassified	27 (3.6)	9 (2.8)	18 (4.2)	
CSC score at 2010				
median (IQR)	14 (11, 18)	16 (13, 19)	13 (10, 17)	<0.001
Academic hospital	90 (12.1)	61 (18.9)	29 (6.8)	<0.001
DPC hospital	553 (73.8)	237 (73.4)	316 (74.2)	0.804
Number of beds				<0.001
<99	50 (6.7)	19 (5.9)	31 (7.3)	
100-299	232 (31.0)	75 (23.2)	157 (36.9)	
300-499	260 (34.7)	105 (32.5)	155 (36.4)	
≥500	207 (27.6)	124 (38.4)	83 (19.5)	
Annual stroke volume				<0.001
<99	129 (17.2)	36 (11.2)	93 (21.8)	

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100-199	199 (26.5)	76 (23.5)	123 (28.9)	
200-299	155 (20.7)	70 (21.7)	85 (20.0)	
≥300	228 (30.4)	127 (39.3)	101 (23.7)	
N/A	38 (5.1)	14 (4.3)	24 (5.6)	
Number of stroke physicians, median (IQR)	4 (3, 7)	5 (3, 9)	4 (2, 6)	<0.001

*DPC: Diagnostic Procedure Combination, Hsp: hospital, MEA: metropolitan, McEA: micropolitan

Supplemental Appendix 1. List of the J-ASPECT Study Collaborators.

All Contributors were involved in collection of data.

Hospitals	Responsible persons
Ainomiyako Neurosurgery Hospital	Isao Sasaki
Aizawa Hospital	Takao Hasimoto
Akita University Hospital	Hiroaki Shimizu
Akocity Hospital	Minoru Asahi
Almeida Memorial Hospital	Makoto Goda
Aomori City Hospital	Atsuhito Takemura
Aomori Prefectural Central Hospital	Tatsuya Sasaki
Asahi General Hospital	Saburo Watanabe
Ashiya Municipal Hospital	Seiko Kataoka
Atsuchi Neurosurgical Hospital	Kouji Takasaki
Ayabe City Hospital	Kouji Shiga
Baba Memorial Hospital	Hidehuku Gi
Bellland General Hospital	Ryunosuke Uranishi
Beppu Medical Center	Yasuyuki Nagai
Chiba Cancer Center	Toshihiko Iuchi
Chiba Cerebral and Cardiovascular Center	Toshio Machida, Junichiro Shimada
Chiba Neurosurgical Clinic	Kenji Wakui
Chiba Rosai Hospital	Takashi Saegusa

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Chiba Tokushukai Hospital	Isao Kitahara
Chidoribashi Hospital	Yasushi Ejima
Chigasaki Municipal Hospital	Takaakira Yokoyama
Chikamori Hospital (Chikamori Health Care Group)	Satoru Hayashi
Chutoen General Medical Center	Toshikazu Ichihashi
Corporate Medical Association Shoikai Kasai Shoikai Hospital	Junichi Harashina
Daiichitowakaihospital	Tsugumichi Ichioka
Daiyukai General Hospital	Takayuki Kato, Shinichi Shirakami
Date Red Cross Hospital	Takeshi Matsuoka
Department of Neurosurgery Shiroyama Hospital	Kenichi Murao
Dokkyo Medical University Koshigaya Hospital	Akio Hyodo, Tomoyuki Miyamoto
Doutounoushinnkeigekabyouinn	Teruo Kimura
Ebina General Hospital	Tomonori Kobayashi
Ehime Prefectural Central Hospital	Shinji Iwata
Faculty of Medicine, Saga University	Tatsuya Abe
Faculty of Medicine, University of Miyazaki	Hideo Takeshima
Fuchu Hospital	Kazunori Yamanaka
Fuji City General Hospital	Satoru Morooka
Fujii Neurosurgical Hospital	Hideo Kunimine
Fujita General Hospital	Satoshi Taira
Fujita Health University Hospital	Ichiro Nakahara, Yuichi Hirose

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5	Fujiyoshida Municipal Hospital	Syougo Imae
6	Fukaya Red Cross Hospital	Hirochiyo Wada
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8	Fukuchiyama City Hospital	Mamoru Murakami
9		
10	Fukui Katsuyama General Hospital	Masanori Kabuto
11	Fukuoka Seisyukai Hospital	Masaharu Tani, Isao Inoue
12		
13	Fukuoka Tokushukai Medical Center	Hidenori Yoshida
14		
15	Fukuoka University Chikushi Hospital	Kiyoshi Kazekawa
16	Fukuoka University Hospital	Tooru Inoue
17		
18	Fukuoka Wajiro Hospital	Kouzou Fukuyama
19		
20	Fukuokashinmizumaki Hospital	Shigenari Kin
21	Fukushima Medical University Hospital	Taku Sato
22		
23	Fukushima Red Cross Hospital	Yoichi Watanabe
24		
25	Gifu Municipal Hospital	Tetsuya Tanigawara
26	Gifu Prefectural Tajimi Hospital	Junki Ito
27		
28	Gifu University Hospital	Toru Iwama
29		
30	Hachisuga Hospital	Yoshihisa Maeda
31	Hakodate Central General Hospital	Makoto Takeda
32		
33	Hakodate Municipal Hospital	Jun Niwa
34		
35	Hakodate Neurosurgical Hospital	Mikio Nishiya
36	Hakujuji Hospital	Shuji Hayasi
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38	Hamamatsu Medical Center	Teiji Nakayama
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Hamanomachi Hospital	Koichirou Matsukado
Harasanshin Hospital	Tadahisa Shono
Hata Kenmin Hospital	Hiroyuki Nishimura
Higashiosaka City Medical Center	Takatoshi Fujimoto, Ryo Tamaki
Higashitotsuka Memorial Hospital	Satoshi Utsuki
Higashiyamato Hospital	Ikuo Kobayashi, Hirotooshi Ohtaka
Hirosaki Stroke and Rehabilitation Center	Takamitsu Uchizawa
Hirosaki University Hospital	Hiroki Ohkuma
Hiroshima City Hiroshima Citizens Hospital	Shigeki Nishino
Hiroshima Prefectural Hospital	Atsushi Tominaga
Hiroshima Red Cross Hospital & Atomic Bomb Survivors Hospital	Masayuki Sumida
Hiroshima University Hospital	Takahito Okazaki, Shirou Aoki
Hito Medical Center	Naoki Shinohara
Hokkaido Medical Center	Satoshi Ushikoshi
Hokkaido University Dept. Neurosurgery	Syunsuke Terasaka, Kiyohiro Houkin
Hokushikai Megumino Hospital	Mitsunobu Kaijima
Hokuto Hospital	Kimito Kondo, Kazumi Nitta
Hospital	Toshiki Ikeda, Hidetoshi Ooigawa
Hospital Nanbu Tokushukai	Tutomu Kadokaru
Hukuoka City Hospital	Katsuyuki Hirakawa
Hyogo College of Medicine	Shinichi Yoshimura

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5	Hyogo Prefectural Awaji Medical Center	Yoshio Sakagami
6	Hyogo Prefectural Kakogawa Medical Center	Hideo Aihara
7		
8	Hyogokenritu_Nishinomiya_Hospital	Takayuki Sakaki
9		
10	Ibaraki Prefectural Central Hospital	Hiroko Oyama, Yuuji Kujiraoka
11	Ibaraki Seinan Medical Center Hospital	Keishi Fujita
12		
13	Iida Municipal Hospital	Sumio Kobayashi
14		
15	Imari Arita Kyoritsu Hospital	Nobuaki Momozaki
16	Ina Central Hospital	Atsushi Sato
17		
18	Inagi Municipal Hospital	Hideki Murakami, Tatsuo Iwasita
19		
20	Institute of Brain and Blood Vessels Mihara Memorial Hospital	Akazi Kazunori, Takao Kanzawa
21	Irixyouhoujin Okinawatokushuukai Uwajimatokushukai Hospital	Hiromichi Sadashima
22		
23	Iryohojin Seiwakai Wada Hospital	Shiro Miyata
24		
25	Iryouhoujinsyadanjinmeikai Akiyamanousinnkeigeka	Takekazu Akiyama
26		
27	Iryouhouzinsyadan Meihoukai	
28	Yokohamashintoshinoushinkeigekabyouin	Akihiro Nemoto, Masafumi Morimoto
29		
30	Isahaya General Hospital	Yoshihiro Nishiura
31	Ise Red Cross Hospital	Fumitaka Miya, Masunari Sibata
32		
33	Ishikawa Prefectural Central Hospital	Yutaka Hayashi
34		
35	Ishinomaki Red Cross Hospital	Syuichi Ishikawa
36		
37	Itabashi Chuo Medical Center	Miura Naohisa
38	Itami Kousei Neurosurgical Hospital	Shinya Noda
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Iwaki Kyoritsu General Hospital	Yasuhiro Suzuki
Iwata Municipal General Hospital	Shinji Amano
Iwate Medical University	Kuniaki Ogasawara
Iwate Prefectural Central Hospital	Takayuki Sugawara
Iwate Prefectural Iwai Hospital	Keiichi Saitou
Iwate Prefectural Kuji Hospital	Kazuyuki Miura
Iwate Prefectural Ninohe Hospital	Akinori Yabuta
Izumi Hospital	Makoto Hasebe
Izumino Hospital	Masato Seike
Japan Community Health Care Organization Chukyo Hospital	Akira Ikeda
Japan Community Health Care Organization Kyushu Hospital	Satoshi Inoha
Japan Community Health Care Organization Tokyo Takanawa Hospital	Hirofumi Hiyama
Japan Organization of Occupational Health and Safety Kumamoto Rousai Hospital	Hiromasa Tsuiki, Shigeo Yamashiro
Japanese Red Cross Akita Hospital	Keiichi Nishimaki
Japanese Red Cross Asahikawa Hospital	Katsumi Takizawa, Kenichi Makino
Japanese Red Cross Fukuoka Hospital	Hitoshi Tsugu, Jiro Kitayama
Japanese Red Cross Kitami Hospital	Nozomi Suzuki
Japanese Red Cross Kumamoto Hospital	Shu Hasegawa, Tadashi Terasaki
Japanese Red Cross Maebashi Hospital	Ken Asakura

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5	Japanese Red Cross Medical Center	Ichiro Suzuki
6	Japanese Red Cross Society Hachinohe Hospital	Hiromu Konno
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8	Japanese Red Cross Takayama Hospital	Katsunobu Takenaka
9		
10	Japanese Redcross Fukui Hospital	Hiroki Toda, Taketo Hatano
11	Jcho Hitoyoshi Medical Center	Keizou Yamamoto
12		
13	Jcho Kobe Central Hospital	Keigo Matsumoto
14		
15	Jcho Kumamoto General Hospital	Kazunari Koga
16	Jcho Nankai Medical Center	Takamitu Hikawa
17		
18	Juntendo Universty Hospital	Hajime Arai
19		
20	Kaetsu Hospital	Kazuaki Awamori
21	Kaga Medical Center	Naoki Shirasaki
22		
23	Kagawa Rosai Hospital	Kimihiro Yoshino
24		
25	Kagawa University Hospital	Takashi Tamiya
26	Kagoshima City Hospital	Kazuho Hirahara
27		
28	Kagoshima Prefectural Kanoya Medical Center	Shunichi Tanaka
29		
30	Kagoshima Tokushukai Hospital	Teruaki Kawano
31	Kagoshima University Hospital	Sei Sugata, Kazunori Arita
32		
33	Kan-Etsu Hospital	Masahiko Tanaka
34		
35	Kanazawa Medical Univercity	Shunsuke Shiraga
36	Kanazawa Neurosurgical Hospital	Syuji Sato
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38	Kanazawa University Hospital	Mitsutoshi Nakada
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Kaneda Hospital
Kanmon Medical Center
Kano Hospital
Kansai Electric Power Hospital
Kansai Medical University Hospital
Kanto Rosai Hospital
Kasaoka Daiichi Hospital
Kashiwaba Neurosurgical Hospital
Kasugai Municipal Hospital
Kawasaki Medical School Hospital
Kazuno Kosei Hospital
Keiju Medical Center
Keishunkai Medical Corporation Kobari General Hospital
Kenwakai Hospital
Kenwakai Otemati Hospital
Kieikai Hospital
Kindai University Hospital
Kindai University Sakai Hospital
Kiryu Kosei General Hospital
Kishiwada City Hospital
Kishiwada Tokushukai Hospital

Kimihisa Kinoshita
Katsuhiro Yamashita
Nakazawa Kazutomo
Yasuhiro Fujimoto
Kunikazu Yoshimura
Takayuki Tachizawa
Akira Watanabe
Tetsuyuki Yoshimoto
Naoto Kuwayama
Masaaki Uno
Masayuki Sasou
Sotaro Higashi
Naoaki Sato
Masakazu Kitahara
Hiroshi Yoneda
Satoshi Suzuki
Toshiho Ohtsuki, Amami Kato
Yusaku Nakamura
Satoshi Magarisawa
Kenji Hashimoto
Hiroyuki Matsumoto

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5	Kita-Harima Medical Center	Hirotooshi Hamaguchi, Shigeru Miyake
6	Kitakami Saiseikai Hospital	Tomohiko Satou
7		
8	Kitakyusyu General Hospital	Masaru Idei
9		
10	Kitakyusyu Municipal Medical Center	Masahiro Mizoguchi
11	Kitamura Hospital	Eiichiro Kamatsuka
12		
13	Kitasato University School of Medicine	Toshihiro Kumabe
14		
15	Kobe City Medical Center General Hospital	Nobuyuki Sakai
16	Kobe Ekisaikai Hospital	Takashi Tominaga
17		
18	Kobe Red Cross Hospital	Haruo Yamashita
19		
20	Kobe University Hospital	Eiji Kohmura, Tatsushi Toda
21	Kochi Health Sciences Center	Tsuyoshi Oota, Masanori Morimoto
22		
23	Kochi Medical School Hospital	Tetsuya Ueba
24		
25	Kohka Public Hospital	Kazuyoshi Watanabe
26	Kohnan Hospital	Hidenori Endo
27		
28	Kohsei General Hospital	Kenjiro Hujiiwara, Minoru Nakagawa
29		
30	Kokura Memorial Hospital	Taketo Hatano, Akira Ishii
31	Komaki City Hospital	Toshinori Hasegawa
32		
33	Komatsu Municipal Hospital	Hisashi Nitta
34		
35	Komoro Kosei General Hospital	Takayuki Kuroyanagi
36	Koshigaya Municipal Hospital	Akira Tunoda
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38	Koto Memorial Hospital	Hisao Hirai
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Koyama Memorial Hospital
Kugayama Hospital
Kumamoto City Hospital
Kurashiki Central Hospital
Kurashiki Heisei Hospital
Kurosawa Hospital
Kurosishi General Hospital
Kurosu Hospital
Kurume University Hospital

Kyorin University Hospital
Kyoritsu Hospital
Kyoto Okamoto Memorial Hospital
Kyoto Second Red Cross Hospital
Kyoto Univerisity Hospital
Kyoto Yamashiro General Medical Center
Kyotokatsura Hospital
Kyotomin-Iren Chuohospital
Kyushu Central Hospital of The Mutual Aid Association of Public
School Teachers
Kyushu Rosai Hospital

Takuya Kawai
Mitsuyuki Fujitsuka
Akira Takada, Seiji Tajiri
Masaki Chin
Hidemiti Sasayama
Sigehiro Ohmori
Seiko Hasegawa
Kazuhiro Kikuchi, Mikio Teduka
Motohiro Morioka
Yoshiko Unno, Hiroki Yoshida , Teruyuki
Hirano
Masayuki Yokota
Minoru Kidooka
Hiroshi Tenjin
Susumu Miyamoto
Yoshihiro Iwamoto
Yasumasa Yamamoto
Yuko Shikata

Hitonori Takaba
Sei Haga



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5	Kyushu University Hospital	Koji Iihara
6	Local Incorporated Administrative Agency Tokushima Prefecture	
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8	Naruto Hospital	Masahito Agawa
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10	Makita General Hospital	Yoshinori Arai
11		
12	Maruko Central Hospital	Toshiyuki Tsukada
13		
14	Matsushita Memorial Hospital	Nozomu Murai
15		
16	Matsuyama Shimin Hospital	Masakazu Suga
17		
18	Mazda Hospital	Kawamoto Yukihiko
19		
20	Medical Corporation Ijinkai Nakamura Memorial Hospital	Kenji Kamiyama
21		
22	Medical Corporation Meiseikai Abashiri Neurosurgicalrehabilitation	
23	Hospital	Naoto Izumi
24		
25	Meitetsu Hospital	Youtarou Takeuchi
26		
27	Midorigaoka Hospital	Motohiro Arai
28		
29	Mie University Hospital	Hidenori Suzuki
30		
31	Mimihara General Hospital	Shinji Okumura
32		
33	Minamata City General Hospital and Medical Center	Makoto Yoshikawa
34		
35	Minami Wakayama Medical Center	Yoshinari Nakamura
36		
37	Minato Medical Coop-Kyoritsu General Hospital	Hisashi Tanaka
38		
39	Mito Kyodo General Hospital	Yasusi Sibata
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41	Mitoyogeneralhospital	Tetsuya Masaoka
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43	Mitsugi General Hospital	Takashi Matsuoka
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Miyakonojo Medical Association Hospital

Hajime Ohta

Miyoshi Central Hospital

Osamu Hamasaki

Moriguchi-Ikuno Memorial Hospital

Misao Nishikawa

Morioka Red Cross Hospital

Naohiko Kubo

Munakata Suikokai General Hospital

Yosimasa Kinoshita

Muroran City General Hospital

Hiroshi Ooyama

Nagahama City Hospital

Taro Komuro

Nagano Municipal Hospital

Yoshikazu Kusano

Nagaoka Chuo General Hospital

Shigekazu Takeuchi

Nagasaki Kawatana Medical Center

Ei-Ichirou Urasaki

Nagasaki University Hospital

Takayuki Matsuo

Nagasaki Shimabara Hospital

Yoshiharu Tokunaga

Nagoya City University

Mitsuhiro Mase

Nagoya Daini Red Cross Hospital

Yukio Seki, Keizo Yasui

Nagoya University Hospital

Yoshio Araki

Naha City Hospital

Naoki Tomiyama

Nakamura Memorial South Hospital

Taiichiro Watanabe, Koji Oka

Nakatsu Municipal Hospital

Hiromichi Koga

Nara Medical University

Hiroyuki Nakase

Narita Red Cross Hospital

Michio Nakamura

National Cerebral and Cardiovascular Center

Jun Takahashi

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5	National Hospital Organization Chiba Medical Center	Hirokazu Tanno
6	National Hospital Organization Hamada Medical Center	Takato Kagawa
7		
8	National Hospital Organization Himeji Medical Center	Osamu Narumi
9		
10	National Hospital Organization Kyushu Medical Center	Akira Nakamizo, Shinji Nagata
11	National Hospital Organization Nagoya Medical Center	Noriyuki Suzaki
12		
13	National Hospital Organization Okayama Medical Center	Yoichiro Namba
14		
15	National Hospital Organization Osakaminami Medical Center	Tomonori Yamada
16	National Hospital Organization Tochigi Medical Center	Masayuki Ishihara
17		
18	National Hospital Organization Toyohashi Medical Center	Hideki Sakai
19		
20	National Hospital Organization Ureshino Medical Center	Masayuki Miyazono
21	National Hospital Organization, Iwakuni Clinical Center	Kotaro Ogihara
22		
23	Nayoro City Hospital	Naoki Tokumitsu
24		
25	Nho Sendai Medical Center	Masayuki Ezura
26		
27	Nho Shinshu Ueda Medical Center	Keiichi Sakai
28		
29	Nihon University Itabashi Hospital	Atsuo Yoshino
30		
31	Niigata City General Hospital	Kenichi Morita, Akihiko Saito
32		
33	Niigata Prefectural Central Hospital	Igarashi Michitoku
34		
35	Niigata Tokamachi Hospital	Mitsuo Kouno
36		
37	Niigata University Medical and Dental Hospital	Yukihiko Fujii, Osamu Onodera
38		
39	Niigatanougekabyouin	Kiyoshi Onda
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41	Nishikobe Medical Center	Naoya Takeda
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Nishinomiya Kyoritsu Neurosurgical Hospital	Hiroji Miyake
Nishio Municipal Hospital	Toshio Yokoe
Nishitokyo Central General Hospital	Tatsuya Nakamura
Nissan Tamagawa Hospital	Takayuki Kubodera
Nitobe Memorial Nakano General Hospital	Mitsuhiro Hokari
Noshiro Kosei Medical Center	Yasunari Otawara
Noto General Hospital	Cheho Park
Nozaki Tokushukai Hospital	Hidemitsu Nakagawa
Obara Hospital	Souichi Obara
Obase Hospital	Haruki Takahashi
Obihiro Kosei General Hospital	Masafumi Ohtaki
Odate Municipal General Hospital	Atsuya Okubo
Ogaki Tokushukai Hospital	Katsuhiko Hayashi
Ohnishi Neurological Center	Hideyuki Ohnishi, Yoshihiro Kuga
Ohta Nishinouchi Hospital	Masahisa Kawakami
Oita Prefectural Hospital	Yu Takeda
Oitaken Koseiren Tsurumi Hospital	Akihiko Kaga
Okaya City Hospital	Ryoichi Hayashi
Okayama City Hospital	Koji Tokunaga
Okayama Kyokuto Hospital	Hiroyuki Nakashima
Okayama University Hospital	Isao Date

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5	Okinawa Kyodo Hospital	Koji Idomari, Nobuyuki Kaneko
6	Okinawa Prefectural Nanbu Medical Center and Children's Medical	
7	Center	Tomoaki Naganine
8		
9	Okitama Public General Hospital	Toshihiko Kinjo
10		
11	Ome Municipal General Hospital	Yoshiaki Takada, Osamu Tao
12		
13	Omihachiman Community Medical Center	Masayuki Nakajima
14		
15	Omori Red Cross Hospital	Akira Isoshima
16		
17	Omuta City Hospital	Terukazu Kuramoto
18		
19	Onomichi Municipal Hospital	Shigeru Daido
20		
21	Osaka Medical College	Toshihiko Kuroiwa
22		
23	Osaka National Hospital	Kazuo Hashikawa
24		
25	Osaka Neurological Institute	Akatsuki Wakayama
26		
27	Osaka Neurosurgical Hospital	Naoki Hayashi
28		
29	Osaka University Hospital	Kouich Iwatsuki, Toshiki Yoshimine
30		
31	Osaki Citizen Hospital	Masahiro Yoshida
32		
33	Otaru General Hospital	Yoshimasa Niiya
34		
35	Otsu City Hospital	Motohiro Takayama
36		
37	Otsu Red Cross Hospital	Masaaki Saiki
38		
39	Rakuwakaiotowa Hospital	Kazuo Yamamoto
40		
41	Research Institute For Brain and Blood Vessels-Akita	Junta Moroi, Taizen Nakase, Tatsuya Ishikawa
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43	Saga-Ken Medical Centre Koseikan	Shuji Sakata, Hiroshi Sugimori
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Saiseikai Futsukaichi Hospital	Naoko Fujimura
Saiseikai Imabari Hospital	Osamu Nishizaki
Saiseikai Kumamoto Hospital	Toru Nishi
Saiseikai Kurihashi Hospital	Hiroshi Wanihuti
Saiseikai Kyoto Hospital	Nobukuni Murakami
Saiseikai Matsusaka General Hospital	Hiroto Murata
Saiseikai Nagasaki Hospital	Wataru Haraguchi
Saiseikai Toyama Hospital	Yukio Horie
Saiseikai Yahata General Hospital	Yuji Okamoto
Saiseikai Yokohamashi Tobu Hospital	Makoto Inaba
Saiseikaiustunomiya Hospital	Masashi Nakatsukasa
Saitama City Hospital	Atsuhiko Kojima
Saitama Medical Center	Kyoichi Nomura
Saitama Red Cross Hosoi Hospital	Toshie, Yamamoto Kenji Takahashi
Sakai City Medical Center	Yoshikazu Nakajima
Saku Central Hospital Advanced Care Center	Takaaki Yoshida
Sanyudohospital	Yohei Kudoh
Sapporo Azabu Neurosurgical Hospital	Toshitaka Nakamura
Sapporo Medical University Hospital	Nobuhiro Mikuni
Sapporo Shiroishi Memorial Hospital	Akira Takahashi
Sapporoteishinkaihospital	Rokuya Tanikawa

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5	Sasebo Chuo Hospital	Seisaburo Sakamoto
6	Secomedic Hospital	Seiichiro Hoshi
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8	Seikeikai Hospital	Yoshinari Okumura
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10	Seirei Memorial Hospital	Sinichi Okabe
11	Seirei Mikatahara General Hospital	Haruhiko Sato
12		
13	Sendai City Hospital	Hiroshi Karibe
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15	Shakaiiryohoujinzaidanshinwakaiyachiyobyuin	Takashi Inoue
16	Shikoku Medical Center For Children and Adults	Kazuyuki Kuwayama
17		
18	Shimane Prefectural Central Hospital	Tatsuya Mizoue
19		
20	Shimizu Hospital	Takashi Yoshida
21	Shimonoseki City Hospital	Takaharu Nakamura
22		
23	Shin Koga Hospital	Tsutomu Hitotsumatsu
24		
25	Shin-Oyama City Hospital	Tomoaki Kameda
26	Shingu Municipal Medical Center	Mitsukazu Nakai, Hiroshi Ishiguchi
27		
28	Shinonoi General Hosapital	Masanobu Hokama
29		
30	Shinsapporo Neurosurgical Hospital	Akinori Yamamura
31	Shinshu University Hospital	Kazuhiro Hongo
32		
33	Shinsuma General Hospital	Takeshi Kondoh
34		
35	Shintakeohospital	Makoto Ichinose
36	Shizuoka Children's Hospital	Yuzuru Tashiro
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38	Shizuoka City Shizuoka Hospital	Seiji Fukazawa
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Shonan Kamakura General Hospital	Takahisa Mori
Showa Inan General Hospital	Shinsuke Muraoka
Showa University Fujigaoka Hospital	Tomoaki Terada
Shuuwa General Hospital	Tsuneo Shishido
Social Welfare Organization Saiseikai Imperial Gift Foundation Inc.	
Osaka Saiseikai Ibaraki Hospital	Yasunobu Gotou
Social Welfare Organization Saiseikai Imperial Gift Foundation Inc. Yamagata Saisei	Sunao Takemura
South Miyagi Medical Center	Hiroaki Arai
Southern Tohoku Hospital	Zenichiro Watanabe
St. Marianna University School of Medicine	Yuichiro Tanaka
St. Luke's International Hospital	Yasunari Niimi
Steel Memorial Yawata Hospital	Shinya Yamaguchi, Akira Nakamizo
Suiseikai Kajikawa Hospital	Shinichi Wakabayashi
Suwa Central Hospital	Hiroki Sato
Suwa Red Cross Hospital	Yukinari Kakizawa
Syakaiiryohouzin Kouseikai Takai Hospital	Tetsuya Morimoto
Tachibana Medical Corporation Higashisumiyoshi Morimoto Hospital	Naofumi Isono
Tachikawa General Hospital	Hiroki Takano, Hiroshi Abe
Takamatsu Municipal Hospital	Norihito Shirakawa
Takamatsu Red Cross Hospital	Masahiro Kagawa

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5	Takarazuka City Hospital	Eiichiro Mabuchi
6	Takarazuka Daiichi Hospital	-
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8	Takatsuki General Hospital	Kazusige Maeno
9		
10	Takeda General Hospital Organization	Takayuki Koizmi
11	Takeda Hospital	Waro Taki
12		
13	Takikawa Neurosurgical Hospital	Yusuke Nakagaki
14		
15	Tanushimaru Central Hospital	Yoshihisa Matumoto
16	Teinekeijinkai Hospital	Katuyuki Asaoka
17		
18	Tenri Hospital	Yoshinori Akiyama
19		
20	Tenshindo Hetsugi Hospital	Tadao Kawamura
21		
22	Teraoka Memorial Hospital	Atumi Takenobu
23	The Veritas Hospital	Masayuki Yokota
24		
25	Tobata Kyoritu Hospital	Taketoshi Tuji
26		
27	Tohoku University Hospital	Teiji Tominaga
28	Tokai University Hachioji Hospital	Shigeru Nogawa, Masami Shimoda
29		
30	Toki General Hospital	Sinji Noda
31		
32	Tokushima Red Cross Hospital	Hajimu Miyake
33	Tokushima University Hospital	Shinji Nagahiro, Junichiro Satomi
34		
35	Tokuyama Central Hospital	Kunihiko Harada
36		
37	Tokyo Dental College Ichikawa General Hospital	Sadao Suga
38	Tokyo General Hospital	Shinichi Numazawa
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Tokyo Medical and Dental University	Taketoshi Maehara
Tokyo Medical University Hachioji Medical Center	Hiroyuki Jimbo, Jyunya Tsurukiri
Tokyo Medical University Hospital	Michihiro Kohno
Tokyo Metropolitan Hiroo Hospital	Kensaku Yoshida
Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology	Koji Matuoka
Tokyo Metropolitan Tama Medical Center	Takahiro Ota
Tokyo Saiseikai Central Hospital	Haruhiko Hoshino
Tokyo Teisin Hospital	Makoto Noguchi
Tokyo Women's Medical University	Takakazu Kawamata
Tokyo Yamate Medical Center	Yasuaki Takeda
Tomakomaihigashi Hospital	Youichi Hashimoto
Tomei Atsugi Hopital	Keiichirou Onitsuka
Tominaga Hospital	Masahiko Kitano
Tomishiro Central Hospital	Jae-Hyun Son
Tottori Municipal Hospital	Keiichi Akatsuka
Tottori University	Masamichi Kurosaki, Takashi Watanabe
Toyama City Hospital	Miyamori Tadao
Toyama Prefectural Central Hospital	Hiroaki Hondo
Toyama Red Cross Hospital	Kazumasa Yamatani, Kotaro Tsumura
Toyama University Hospital	Satoshi Kuroda
Toyohashi Municipal Hospital	Hirofumi Oyama

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5	Toyokawa City Hospital	Takayuki Watanabe
6	Toyooka Hospital	Kazuhiro Tanaka
7		
8	Tsuchiura Kyodo General Hospital	Shinji Yamamoto
9		
10	Tsukuba Medical Center Hospital	Kazuya Uemura
11	Tsuruoka Municipal Shonai Hospital	Hirosi Maruya, Kazuhiko Sato
12		
13	Tsutiura Kyodo Hospital Namegata District Medical Center	Hitoshi Tabata
14		
15	Tsuyama Chuo Hospital	Hideyuki Yoshida
16	Tyuubu Rousai Hospital	Noriaki Matubara
17		
18	Ube Kohsan Industries Hospital	Takafumi Nishizaki
19		
20	Uki General Hospital	Hiroshi Egami
21	University of Fukui Hospital	Osamu Yamamura
22		
23	University of Occupational and Environmental Health	Junkoh Yamamoto
24		
25	University of The Ryukyus Hospital	Shogo Ishiuchi
26		
27		Yuji Matsumaru, Akira Matsumura, Tetsuya
28	University of Tsukuba Hospital	Yamamoto
29		
30	University of Yamanashi	Hiroyuki Kinouchi
31		
32	Urasoe General Hospital	Susumu Mearu
33		
34	Ushioda General Hospital	Hitoshi Ozawa
35	Uwajima City Hospital	Kiichiro Zenke
36		
37	Wakayama Medical University Hospital	Naoyuki Nakao
38	Wakayama Rosai Hospital	Toshikazu Kuwata
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Wakayama-Seikyo Hospital	Teruyuki Habu
Yaizu City Hospital	Seiya Takehara
Yamagata City Hospital Saiseikan	Rei Kondo
Yamagata Prefectural Central Hospital	Takashi Kumagai
Yamagata Prefectural Shinjo Hospital	Keiten So
Yamagata University Hospital	Yukihiko Sonoda
Yamaguchi Prefectural Grand Medical Center	Manabu Urakawa
Yamaguchi Red Cross Hospital	Yasuhiro Hamada
Yamaguchi University Hospital	Michiyasu Suzuki
Yamanashi Prefectural Central Hospital	Shin Nakano, Hidehito Koizumi
Yamanashi Redcross Hospital	Hiroshi Ozawa
Yamanashikouseibyuin	Mikito Uchida
Yamato Municipal Hospital	Masaru Yamada
Yao Tokushukai General Hospital	Takashi Turuno
Yatsuo General Hospital	Ryouichi Masuda
Yawata Medical Center	Makoto Kimura
Yayoigaoka Kage Hospital	Shin-Ichiro Ishihara
Yodogawa Christian Hospital	Masashi Morikawa
Yokohama City Minato Red Cross Hospital	Yasunori Takemoto, Hiroaki Tanaka
Yokohama City University Hospital	Hidetoshi Murata, Nobutaka Kawahara
Yokohama City University Medical Center	Katsumi Sakata

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4 Yokohamasinmidorihospital

Endo Sumio

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6 Yonezawa City Hospital

Tooru Sasaki

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8 Yoshida Hospital

Yasuhisa Yoshida

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10 Yuaikaihospital

Yoshihumi Teramoto

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	3
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7
Bias	9	Describe any efforts to address potential sources of bias	11
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	10
		(d) If applicable, describe analytical methods taking account of sampling strategy	-
		(e) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	14
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-14
		(b) Indicate number of participants with missing data for each variable of interest	14
Outcome data	15*	Report numbers of outcome events or summary measures	11-14
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	11-13

		which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	11-13
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	11-13
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13,14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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

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6 **Temporal trends and geographical disparities in comprehensive stroke centre**
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8 **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 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 in 2010, 532 in 2014 and 786 in 2018 hospitals that participate in the J-ASPECT study.

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.

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7 **Results:** Among the 323 hospitals that responded to all surveys, the
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10 implementation of 14 recommended items increased. The CSC score (median,
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13 interquartile range) was 16 (13-19), 18 (14-20), 19 (15-21), for 2010, 2014, and
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16 2018, respectively ($p < 0.001$). There was a $\geq 20\%$ increase in six items (e.g.
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19 endovascular physicians, stroke unit, and interventional coverage 24/7), and a \leq
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22 20% decrease in community education. A lower baseline CSC score (odds ratio
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25 0.82, [95% confidence interval] 0.75-0.9), the number of beds ≥ 500 (3.9 [1.2–
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28 13.0]), and the number of stroke physicians (7-9) (2.6 [1.1-6.3]) was associated
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33 with improved CSC capabilities, independent of geographical location.

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36 **Conclusions:** There was a significant improvement in CSC capabilities between
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39 2010 and 2018, which was mainly related to the availability of endovascular
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42 treatment and multidisciplinary care. Our findings may be useful to determine
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45 which hospitals should be targeted to improve CSC capabilities in a defined
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48 area.
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56 **Strengths and limitations of this study:**
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- A large-scale, representative hospitals of Japan provided data on temporal trends in the 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} number of physicians, and geographical locations of the facility⁷. Progressive rural-urban disparities in acute stroke care have been reported in the United States,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

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6 registry. We demonstrated significant geographical differences in CSC
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9 capabilities in 2010,⁹ and that CSC capabilities of a facility are associated with
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11 reduced in-hospital mortality from acute stroke.¹⁰ Thus continuous monitoring
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13 of the CSC capabilities may be clinically meaningful to improve stroke
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15 outcomes.^{10, 11} Since 2010, we have conducted nationwide benchmark analyses
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17 to allow participating hospitals to facilitate improvement of stroke care.
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20 However, it remains unclear whether there are improving trends in the CSC
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22 capabilities, or how hospital-related factors determine quality improvement.
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36 AIMS

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38 We aimed to examine whether CSC capabilities in Japan changed from 2010 to
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40 2018 and whether any recorded changes were influenced by hospital
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42 characteristics.
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53 METHODS

54 Institutional survey of CSC capabilities

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

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46 All items were classified into five categories: personnel, diagnostic, specific
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49 expertise, infrastructure, and education. A score of 1 was assigned for meeting
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53 each item, yielding a total CSC score of up to 25. Content, constructs, and
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56 predictive validity of this scoring system have been previously reported.^{12, 13}
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Other hospital characteristics

Hospital characteristics including number of beds, annual stroke hospitalisations, stroke physicians, academic status, adoption of the Diagnosis Procedure Combination (DPC)-based payment system⁹, 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. 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

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6 on the change in CSC capabilities, we divided the hospitals into those with or
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10 without a temporal improvement of CSC score (≥ 1 -point increase between 2010
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13 and 2018). The increase of “One point” was set based on our previous report on
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16 the CSC score.¹¹ In that study, we showed that even a small preceding
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19 improvement of the CSC score was associated with reduced in-hospital
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22 mortality, reduced poor outcomes, and higher use of acute reperfusion therapy
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25 in AIS patients; our findings also suggested the difficulty in improving the CSC
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28 score in a relatively short time period.
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33 We used a chi-squared test to detect differences between consecutively participating
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36 hospitals and other hospitals in the number of each hospital item. We did not perform
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39 multiple tests. Wilcoxon rank sum test was used to compare total CSC scores between
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42 consecutively participating hospitals and other hospitals.
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46 To explore the influence of hospital-related factors on temporal improvement of
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49 CSC capabilities, multiple logistic regression models were used. To assess
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52 selection bias, we compared hospital characteristics between consecutively
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55 participating hospitals with the others. We also examined the relationship between
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7 “number of physicians” and “hospital size” and the relationship between “number of
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10 physicians” and “CSC score” using chi-squared tests. All analyses were performed
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13 using the JMP Statistical Version 12 Software (SAS Institute Inc., Cary, NC,
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16 USA). P values of <0.05 were considered statistically significant.
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23 **Patient and public involvement**

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26 Data for this study are based on information collected by the J-ASPECT study.
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30 Patients and the public were not involved in the development of this study.
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36 **RESULTS**

37 38 39 **Trends in the CSC capabilities from 2010 to 2018**

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42 A total of 749, 532, and 786 hospitals responded to the survey in 2010, 2014, and
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45 2018, respectively. The implementation rates of each item are shown in Table 1.
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49 The median (interquartile range) of the CSC scores was 14 (11-18), 17 (13-19),
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52 and 17 (12-20.3), for each year, respectively (Table 1).
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56 Among consecutively participating hospitals, there was an increase in
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7 implementation rates of the 14 items, and the CSC scores were (median,
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10 interquartile range): 16 (13-19), 18 (14-20), 19 (15-21), for 2010, 2014, and 2018,
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13 respectively ($p < 0.001$) (Table 1). A marked increase ($\geq 20\%$) was noted in six
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16 items related to endovascular treatment (endovascular physicians and
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19 interventional coverage 24/7) and multidisciplinary care (stroke unit, specialists
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22 of emergency medicine and physical medicine/rehabilitation, and stroke
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27 rehabilitation nurses).

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30 In addition, a moderate increase ($\leq 20\%$) was noted in eight items: 24/7
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33 availability of diffusion-weighted magnetic resonance imaging, digital and CT
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36 angiography, carotid ultrasound, coiling of an intracranial aneurysm, and
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39 implementation of stroke registry. In contrast, there was a marked decrease
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43 ($\leq 20\%$) in community education.
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50 **Geographical differences in CSC capabilities between 2010 and 2018**

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53 Among the seven items with significant geographical differences in 2010, all
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56 items in the personal component still showed a gap, despite overall
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6 improvement at all locations in 2018 (Table 2). In contrast, geographical
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9 differences in all infrastructure items diminished with overall improvement
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12 and a marked improvement in the McEA in 2018.
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16 Over the study period, geographical differences emerged in intra-arterial
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18 reperfusion therapy and the number of specialists in physical
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20 medicine/rehabilitation. The remaining item, coiling of intracranial aneurysms,
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22 showed no changes.
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33 **Influence of hospital characteristics on change in CSC capabilities**

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35 Among consecutively participating hospitals, 23 were excluded due to missing
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37 data. Temporal improvement of CSC capabilities between 2010 and 2018 was
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39 noted in 198 hospitals (66.0%). As for hospital characteristics, there were weakly
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41 significant differences in bed number ($p=0.016$) and CSC score in 2010 ($p=0.032$)
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43 between the two groups on univariable analysis (Table 3).
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53 In the logistic regression analyses, the following variables had an association
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55 with temporal improvement of CSC capabilities (Table 4): a lower baseline CSC
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6 score (odds ratio 0.82 [95% confidence interval 0.75-0.9]), bed volume ≥ 500 (3.90,
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9 [1.17–13.0]), and moderate (7-9) number of stroke physicians (2.63, [1.10-6.27]).

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13 In contrast, geographical location, academic status, DPC-based payment system,
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16 and case volume of stroke did not show a significant association. We also
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19 performed the logistic regression analysis adjusting tertile, instead of quartile,
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22 of stroke physician volume in addition to the other adjusting factors. Except for
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25 Q3 of stroke physician volume, we found very similar results (Supplementary
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28 Table 1). Additionally, there was a significant relationship between hospital size and
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31 number of physicians ($P < 0.001$), and between CSC score and number of
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34 physicians ($P < 0.001$).
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43 **Selection bias**

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46 The response rates of the 2010, 2014, and 2018 surveys were 55.0%, 39.7%, and
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49 49.9%, respectively. We found that a selection bias did exist; in fact, the total
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52 CSC scores and most of the implementation rates of each item were
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56 significantly higher for the consecutively participating hospitals than for the
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6 others in all three surveys (Table 1). Consecutively participating hospitals were
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10 more likely to be MEA-central, academic, have a larger number of hospital beds,
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13 higher annual stroke admission rate, and more stroke physicians
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16 (Supplementary Table 2).
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27 DISCUSSION

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29 We found an overall improvement in CSC capabilities between 2010 and 2018,
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32 and different trends in geographical disparities for different items. Hospitals
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35 with a higher number of hospital beds, intermediate number of stroke
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38 physicians, and a lower baseline CSC score had a higher likelihood of
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43 improving their CSC capabilities.
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50 **Temporal Changes to CSC capabilities**

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

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30 These findings are consistent with those of prior studies, which have shown
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33 that admission to a stroke unit with organised stroke care is associated with
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36 better quality of care and outcomes in those who experience an acute stroke.^{14 3}
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40 Although the use of mechanical thrombectomy for large vessel acute ischaemic
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43 stroke (AIS) has been rapidly increasing, only 3.3% of 15.1% potentially eligible
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46 AIS patients received it in 2016.¹⁵ Improvement of CSC capabilities, especially
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49 related to endovascular treatment and multidisciplinary care, should contribute
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53 to improved quality of care and outcomes in patients with acute stroke.

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56 The decreased implementation of community education observed in this study
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7 may be explained by the limited number of stroke physicians available for this
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10 purpose due to an increased burden of stroke care (e.g. emergent endovascular
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13 calls).¹⁶ Stroke educational campaigns have the potential to improve
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16 knowledge and awareness, but public campaigns are usually expensive and
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19 short-lived and may not achieve any significant improvement.¹⁷
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26 **Diminished and emerging geographical disparities**

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30 Determining rural/urban differences in CSC capabilities may support the
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33 development of targeted interventions to improve stroke care and outcomes in
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36 rural areas. We found differing trends in implementation of the items according
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39 to personnel and infrastructure components. Rural areas are associated with
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42 reduced access to optimal stroke care and a lower use of acute stroke
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45 intervention.¹⁸ The diminished disparities in implementation of stroke units in
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48 this study might result in a higher use of rt-PA infusion in rural areas.¹⁹
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53 The emerging disparities in implementation of intraarterial reperfusion
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56 therapy deserve some attention. Since the evidence regarding the efficacy of
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6 acute endovascular reperfusion therapy was established in 2015,²⁰ relocation of
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10 relevant specialists might have occurred from rural to urban areas to meet the
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13 urgent need created by more widespread use. In addition, a high prevalence of
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16 neurointerventional physician burnout may require centralisation of acute
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19 endovascular reperfusion treatment.²¹
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26 **Influence of hospital-related factors on improvement of CSC capabilities**

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29 Our study showed the impact of specific hospital-related factors on
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32 improvement of CSC capabilities, which may be useful to determine which
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35 hospitals should be targeted to improve CSC capabilities, and in what regions.
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40 In rural areas, where medical resources are limited, centralisation of acute
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43 stroke care in large hospitals may be needed. We also found a significant
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46 relationship between CSC score and number of physicians. This means that, in
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49 2010, institutions with more physicians tended to have higher baseline CSC scores. The
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52 reason that a physician volume of more than 10 did not affect the improvement of the
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55 CSC score may be explained by the ceiling effect of a high baseline CSC score in 2010.
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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 PSCs (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

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6 because of the small number of participants in that year. Further research is required to
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10 examine the effect of 2014 data on the analysis.
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13 **Conclusions**

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

None declared.

Ethics approval

The study was approved by the Kyushu University Institutional Review Board, which waived the requirement for individual informed consent (No. 28-335)

Data availability statement

We have documented the data, methods, and materials used to conduct the research in this report. The individual patient data are not publicly available because of the memorandum signed by the director of the participating hospitals and the principal investigator of the J-ASPECT Study group.

Authors and contributors

A Kurogi and KI drafted the manuscript. AN, KN, A Kada, DO, AH and KI

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6 were involved in study concept, design and obtaining funding. A Kada, DO,
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10 AH, KO, YS, TK, KA and KI were involved in analysis and of data. KO, YS, TK
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13 and KI were involved in acquisition of data. All authors reviewed the study
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16 report, made comments or suggestions on the manuscript drafts, and approved
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20 the final version.
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39 Collaborators are listed in Supplemental Appendix 1.
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46 **Patient consent for publication**

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49 Not required.
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Table 1. Number (percentage) of the responding hospitals fulfilling the recommended items of comprehensive stroke care capabilities.

Components	Items	2010				2014				2018			
		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
Specific	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
	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

1													
2	Expertise												
3													
4	Clipping of intracranial												
5	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
6													
7	Hematoma												
8	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
9													
10	Coiling of intracranial												
11	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
12													
13	Intra-arterial reperfusion												
14	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
15													
16													
17	Infrastructure												
18	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
19													
20	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
21													
22	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
23													
24	Interventional services												
25	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
26													
27	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
28	Education												
29	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
30													
31	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
32	Total CSC score												
33	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

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35Hsp, hospital; CT, computed tomography; MRI, magnetic resonance imaging; TCD, transcranial Doppler.

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

		a) 2010				b) 2018			
		MEA central	MEA outlying	McEA	P value	MEA central	MEA outlying	McEA	P value
		(n=186)	(n=79)	(n=35)		(n=186)	(n=79)	(n=35)	
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

	Hematoma 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

*MEA metropolitan, McEA microplitan.

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

Hospital-related factors in 2010	all Consecutively participating Hsps. (n=300)	Improvement Hsps. (n=198)	No improvement Hsps. (n=102)	p value [#]
Hospital 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, 19)	16 (13, 18)	17 (13, 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, 9)	6 (3.8, 9)	5 (3, 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)	

*DPC: Diagnostic Procedure Combination, Hsp: hospital, # p value: Improvement vs. No improvement hospitals, MEA:

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

Hospital-related factors in 2010	Odds ratio	95%CI	P value
Hospital locations			
MEA central	ref.		
MEA outlying	1.42	0.76-2.65	0.269
McEA	0.82	0.36-1.86	0.632
CSC score in 2010			
	0.82	0.75-0.90	<0.001
Academic hospital			
	1.37	0.54-3.48	0.506
DPC hospital			
	0.77	0.41-1.42	0.397
Number of beds			
1-99	ref.		
100-299	1.16	0.37-3.66	0.794

300-499	1.68	0.56-5.10	0.358
≥500	3.9	1.17-13.0	0.027
		0	
Annual stroke case volume			
1-99	ref.		
100-199	1.62	0.64-4.07	0.305
200-299	2.41	0.89-6.49	0.083
≥300	2.74	0.99-7.54	0.051
Number of stroke physician volume quartile			
Q1 (0-3)	ref.		
Q2 (4-6)	1.77	0.81-3.88	0.153
Q3 (7-9)	2.63	1.10-6.27	0.030
Q4 (≥10)	1.58	0.57-4.38	0.380

*DPC: Diagnostic Procedure Combination, Hsp: hospital, # p value: Improvement vs. No improvement hospitals, MEA: metropolitan, McEA: micropolitan.

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Supplemental material

eTable 1. Multivariable analysis of the impact of the hospital characteristics on one-point increase of the CSC score

eTable 2. Univariable analysis of association between consecutively participating hospitals in all three surveys and the others

Supplemental Appendix 1. List of the J-ASPECT Study Collaborators.

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eTable 1 Multivariable analysis of the impact of the hospital characteristics on one-point increase of the CSC score

Hospital-related factors in 2010	Odds	95%CI	P value
Hospital locations			
MEA central	ref.		
MEA outlying	1.35	0.36-2.48	0.339
McEA	0.78	0.35-1.75	0.549
CSC score in 2010	0.83	0.76-0.91	<0.001
Academic hospital	1.29	0.52-3.24	0.582
DPC hospital	0.72	0.39-1.34	0.302
Number of beds			
1-99	ref.		
100-299	1.1	0.36-3.41	0.868
300-499	1.82	0.60-5.48	0.285
≥500	3.81	1.16-12.54	0.028
Annual stroke case volume			

1-99	ref.		
100-199	1.68	0.67-4.18	0.267
200-299	2.47	0.92-6.61	0.072
≥300	3.17	1.16-8.66	0.024
Number of stroke physicians, tertile			
T1 (0-4)	ref.		
T2 (4-8)	1.12	0.58-2.16	0.745
T3 (≥9)	1.35	0.57-3.21	0.492

eTable 2 Univariable analysis of association between consecutively participating hospitals in all three surveys and the others

	All Hsps. in 2010 (n=749)	Consecutively participating Hsps. (n=323)	Other Hsps. (n=426)	p value
Hospital location				<0.001
MEA central	381 (50.9)	193 (59.8)	188 (44.1)	
MEA outlying	239 (31.9)	83 (25.7)	156(36.6)	
McEA	102 (13.6)	38 (11.8)	64 (15.0)	
Unclassified	27 (3.6)	9 (2.8)	18 (4.2)	
CSC score at 2010				
median (IQR)	14 (11, 18)	16 (13, 19)	13 (10, 17)	<0.001
Academic hospital	90 (12.1)	61 (18.9)	29 (6.8)	<0.001
DPC hospital	553 (73.8)	237 (73.4)	316 (74.2)	0.804
Number of beds				<0.001
<99	50 (6.7)	19 (5.9)	31 (7.3)	
100-299	232 (31.0)	75 (23.2)	157 (36.9)	
300-499	260 (34.7)	105 (32.5)	155 (36.4)	
≥500	207 (27.6)	124 (38.4)	83 (19.5)	
Annual stroke volume				<0.001
<99	129 (17.2)	36 (11.2)	93 (21.8)	

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100-199	199 (26.5)	76 (23.5)	123 (28.9)	
200-299	155 (20.7)	70 (21.7)	85 (20.0)	
≥300	228 (30.4)	127 (39.3)	101 (23.7)	
N/A	38 (5.1)	14 (4.3)	24 (5.6)	
Number of stroke physicians, median (IQR)	4 (3, 7)	5 (3, 9)	4 (2, 6)	<0.001

*DPC: Diagnostic Procedure Combination, Hsp: hospital, MEA: metropolitan, McEA: micropolitan

Supplemental Appendix 1. List of the J-ASPECT Study Collaborators.

All Contributors were involved in collection of data.

Hospitals	Responsible persons
Ainomiyako Neurosurgery Hospital	Isao Sasaki
Aizawa Hospital	Takao Hasimoto
Akita University Hospital	Hiroaki Shimizu
Akocity Hospital	Minoru Asahi
Almeida Memorial Hospital	Makoto Goda
Aomori City Hospital	Atsuhito Takemura
Aomori Prefectural Central Hospital	Tatsuya Sasaki
Asahi General Hospital	Saburo Watanabe
Ashiya Municipal Hospital	Seiko Kataoka
Atsuchi Neurosurgical Hospital	Kouji Takasaki
Ayabe City Hospital	Kouji Shiga
Baba Memorial Hospital	Hidehuku Gi
Bellland General Hospital	Ryunosuke Uranishi
Beppu Medical Center	Yasuyuki Nagai
Chiba Cancer Center	Toshihiko Iuchi
Chiba Cerebral and Cardiovascular Center	Toshio Machida, Junichiro Shimada
Chiba Neurosurgical Clinic	Kenji Wakui
Chiba Rosai Hospital	Takashi Saegusa

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Chiba Tokushukai Hospital	Isao Kitahara
Chidoribashi Hospital	Yasushi Ejima
Chigasaki Municipal Hospital	Takaakira Yokoyama
Chikamori Hospital (Chikamori Health Care Group)	Satoru Hayashi
Chutoen General Medical Center	Toshikazu Ichihashi
Corporate Medical Association Shoikai Kasai Shoikai Hospital	Junichi Harashina
Daiichitowakaihospital	Tsugumichi Ichioka
Daiyukai General Hospital	Takayuki Kato, Shinichi Shirakami
Date Red Cross Hospital	Takeshi Matsuoka
Department of Neurosurgery Shiroyama Hospital	Kenichi Murao
Dokkyo Medical University Koshigaya Hospital	Akio Hyodo, Tomoyuki Miyamoto
Doutounoushinnkeigekabyouinn	Teruo Kimura
Ebina General Hospital	Tomonori Kobayashi
Ehime Prefectural Central Hospital	Shinji Iwata
Faculty of Medicine, Saga University	Tatsuya Abe
Faculty of Medicine, University of Miyazaki	Hideo Takeshima
Fuchu Hospital	Kazunori Yamanaka
Fuji City General Hospital	Satoru Morooka
Fujii Neurosurgical Hospital	Hideo Kunimine
Fujita General Hospital	Satoshi Taira
Fujita Health University Hospital	Ichiro Nakahara, Yuichi Hirose

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5	Fujiyoshida Municipal Hospital	Syogo Imae
6	Fukaya Red Cross Hospital	Hirochiyo Wada
7		
8	Fukuchiyama City Hospital	Mamoru Murakami
9		
10	Fukui Katsuyama General Hospital	Masanori Kabuto
11	Fukuoka Seisyukai Hospital	Masaharu Tani, Isao Inoue
12		
13	Fukuoka Tokushukai Medical Center	Hidenori Yoshida
14		
15	Fukuoka University Chikushi Hospital	Kiyoshi Kazekawa
16	Fukuoka University Hospital	Tooru Inoue
17		
18	Fukuoka Wajiro Hospital	Kouzou Fukuyama
19		
20	Fukuokashinmizumaki Hospital	Shigenari Kin
21	Fukushima Medical University Hospital	Taku Sato
22		
23	Fukushima Red Cross Hospital	Yoichi Watanabe
24		
25	Gifu Municipal Hospital	Tetsuya Tanigawara
26	Gifu Prefectural Tajimi Hospital	Junki Ito
27		
28	Gifu University Hospital	Toru Iwama
29		
30	Hachisuga Hospital	Yoshihisa Maeda
31	Hakodate Central General Hospital	Makoto Takeda
32		
33	Hakodate Municipal Hospital	Jun Niwa
34		
35	Hakodate Neurosurgical Hospital	Mikio Nishiya
36		
37	Hakujyuji Hospital	Shuji Hayasi
38	Hamamatsu Medical Center	Teiji Nakayama
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Hamanomachi Hospital

Koichirou Matsukado

Harasanshin Hospital

Tadahisa Shono

Hata Kenmin Hospital

Hiroyuki Nishimura

Higashiosaka City Medical Center

Takatoshi Fujimoto, Ryo Tamaki

Higashitotsuka Memorial Hospital

Satoshi Utsuki

Higashiyamato Hospital

Ikuo Kobayashi, Hirotooshi Ohtaka

Hirosaki Stroke and Rehabilitation Center

Takamitsu Uchizawa

Hirosaki University Hospital

Hiroki Ohkuma

Hiroshima City Hiroshima Citizens Hospital

Shigeki Nishino

Hiroshima Prefectural Hospital

Atsushi Tominaga

Hiroshima Red Cross Hospital & Atomic Bomb Survivors Hospital

Masayuki Sumida

Hiroshima University Hospital

Takahito Okazaki, Shirou Aoki

Hito Medical Center

Naoki Shinohara

Hokkaido Medical Center

Satoshi Ushikoshi

Hokkaido University Dept. Neurosurgery

Syunsuke Terasaka, Kiyohiro Houkin

Hokushikai Megumino Hospital

Mitsunobu Kaijima

Hokuto Hospital

Kimito Kondo, Kazumi Nitta

Hospital

Toshiki Ikeda, Hidetoshi Ooigawa

Hospital Nanbu Tokushukai

Tutomu Kadearu

Hukuoka City Hospital

Katsuyuki Hirakawa

Hyogo College of Medicine

Shinichi Yoshimura

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5	Hyogo Prefectural Awaji Medical Center	Yoshio Sakagami
6	Hyogo Prefectural Kakogawa Medical Center	Hideo Aihara
7		
8	Hyogokenritu_Nishinomiya_Hospital	Takayuki Sakaki
9		
10	Ibaraki Prefectural Central Hospital	Hiroko Oyama, Yuuji Kujiraoka
11	Ibaraki Seinan Medical Center Hospital	Keishi Fujita
12		
13	Iida Municipal Hospital	Sumio Kobayashi
14		
15	Imari Arita Kyoritsu Hospital	Nobuaki Momozaki
16	Ina Central Hospital	Atsushi Sato
17		
18	Inagi Municipal Hospital	Hideki Murakami, Tatsuo Iwasita
19		
20	Institute of Brain and Blood Vessels Mihara Memorial Hospital	Akazi Kazunori, Takao Kanzawa
21	Irixyouhoujin Okinawatokushuukai Uwajimatokushukai Hospital	Hiromichi Sadashima
22		
23	Iryohojin Seiwakai Wada Hospital	Shiro Miyata
24		
25	Iryouhoujinsyadanjinmeikai Akiyamanousinnkeigeka	Takekazu Akiyama
26		
27	Iryouhouzinsyadan Meihoukai	
28	Yokohamashintoshinoushinkeigekabyouin	Akihiro Nemoto, Masafumi Morimoto
29		
30	Isahaya General Hospital	Yoshihiro Nishiura
31	Ise Red Cross Hospital	Fumitaka Miya, Masunari Sibata
32		
33	Ishikawa Prefectural Central Hospital	Yutaka Hayashi
34		
35	Ishinomaki Red Cross Hospital	Syuichi Ishikawa
36		
37	Itabashi Chuo Medical Center	Miura Naohisa
38	Itami Kousei Neurosurgical Hospital	Shinya Noda
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Iwaki Kyoritsu General Hospital

Yasuhiro Suzuki

Iwata Municipal General Hospital

Shinji Amano

Iwate Medical University

Kuniaki Ogasawara

Iwate Prefectural Central Hospital

Takayuki Sugawara

Iwate Prefectural Iwai Hospital

Keiichi Saitou

Iwate Prefectural Kuji Hospital

Kazuyuki Miura

Iwate Prefectural Ninohe Hospital

Akinori Yabuta

Izumi Hospital

Makoto Hasebe

Izumino Hospital

Masato Seike

Japan Community Health Care Organization Chukyo Hospital

Akira Ikeda

Japan Community Health Care Organization Kyushu Hospital

Satoshi Inoha

Japan Community Health Care Organization Tokyo Takanawa

Hospital

Hirofumi Hiyama

Japan Organization of Occupational Health and Safety Kumamoto

Rousai Hospital

Hiromasa Tsuiki, Shigeo Yamashiro

Japanese Red Cross Akita Hospital

Keiichi Nishimaki

Japanese Red Cross Asahikawa Hospital

Katsumi Takizawa, Kenichi Makino

Japanese Red Cross Fukuoka Hospital

Hitoshi Tsugu, Jiro Kitayama

Japanese Red Cross Kitami Hospital

Nozomi Suzuki

Japanese Red Cross Kumamoto Hospital

Shu Hasegawa, Tadashi Terasaki

Japanese Red Cross Maebashi Hospital

Ken Asakura

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5	Japanese Red Cross Medical Center	Ichiro Suzuki
6	Japanese Red Cross Society Hachinohe Hospital	Hiromu Konno
7		
8	Japanese Red Cross Takayama Hospital	Katsunobu Takenaka
9		
10	Japanese Redcross Fukui Hospital	Hiroki Toda, Taketo Hatano
11	Jcho Hitoyoshi Medical Center	Keizou Yamamoto
12		
13	Jcho Kobe Central Hospital	Keigo Matsumoto
14		
15	Jcho Kumamoto General Hospital	Kazunari Koga
16	Jcho Nankai Medical Center	Takamitsu Hikawa
17		
18	Juntendo Universty Hospital	Hajime Arai
19		
20	Kaetsu Hospital	Kazuaki Awamori
21	Kaga Medical Center	Naoki Shirasaki
22		
23	Kagawa Rosai Hospital	Kimihiko Yoshino
24		
25	Kagawa University Hospital	Takashi Tamiya
26	Kagoshima City Hospital	Kazuho Hirahara
27		
28	Kagoshima Prefectural Kanoya Medical Center	Shunichi Tanaka
29		
30	Kagoshima Tokushukai Hospital	Teruaki Kawano
31	Kagoshima University Hospital	Sei Sugata, Kazunori Arita
32		
33	Kan-Etsu Hospital	Masahiko Tanaka
34		
35	Kanazawa Medical Univercity	Shunsuke Shiraga
36	Kanazawa Neurosurgical Hospital	Syuji Sato
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38	Kanazawa University Hospital	Mitsutoshi Nakada
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Kaneda Hospital	Kimihisa Kinoshita
Kanmon Medical Center	Katsuhiro Yamashita
Kano Hospital	Nakazawa Kazutomo
Kansai Electric Power Hospital	Yasuhiro Fujimoto
Kansai Medical University Hospital	Kunikazu Yoshimura
Kanto Rosai Hospital	Takayuki Tachizawa
Kasaoka Daiichi Hospital	Akira Watanabe
Kashiwaba Neurosurgical Hospital	Tetsuyuki Yoshimoto
Kasugai Municipal Hospital	Naoto Kuwayama
Kawasaki Medical School Hospital	Masaaki Uno
Kazuno Kosei Hospital	Masayuki Sasou
Keiju Medical Center	Sotaro Higashi
Keishunkai Medical Corporation Kobari General Hospital	Naoaki Sato
Kenwakai Hospital	Masakazu Kitahara
Kenwakai Otemati Hospital	Hiroshi Yoneda
Kieikai Hospital	Satoshi Suzuki
Kindai University Hospital	Toshiho Ohtsuki, Amami Kato
Kindai University Sakai Hospital	Yusaku Nakamura
Kiryu Kosei General Hospital	Satoshi Magarisawa
Kishiwada City Hospital	Kenji Hashimoto
Kishiwada Tokushukai Hospital	Hiroyuki Matsumoto

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5	Kita-Harima Medical Center	Hirotooshi Hamaguchi, Shigeru Miyake
6	Kitakami Saiseikai Hospital	Tomohiko Satou
7		
8	Kitakyusyu General Hospital	Masaru Idei
9		
10	Kitakyusyu Municipal Medical Center	Masahiro Mizoguchi
11	Kitamurayama Hospital	Eiichiro Kamatsuka
12		
13	Kitasato University School of Medicine	Toshihiro Kumabe
14		
15	Kobe City Medical Center General Hospital	Nobuyuki Sakai
16	Kobe Ekisaikai Hospital	Takashi Tominaga
17		
18	Kobe Red Cross Hospital	Haruo Yamashita
19		
20	Kobe University Hospital	Eiji Kohmura, Tatsushi Toda
21	Kochi Health Sciences Center	Tsuyoshi Oota, Masanori Morimoto
22		
23	Kochi Medical School Hospital	Tetsuya Ueba
24		
25	Kohka Public Hospital	Kazuyoshi Watanabe
26	Kohnan Hospital	Hidenori Endo
27		
28	Kohsei General Hospital	Kenjirou Hujiwara, Minoru Nakagawa
29		
30	Kokura Memorial Hospital	Taketo Hatano, Akira Ishii
31	Komaki City Hospital	Toshinori Hasegawa
32		
33	Komatsu Municipal Hospital	Hisashi Nitta
34		
35	Komoro Kosei General Hospital	Takayuki Kuroyanagi
36	Koshigaya Municipal Hospital	Akira Tunoda
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38	Koto Memorial Hospital	Hisao Hirai
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Koyama Memorial Hospital
Kugayama Hospital
Kumamoto City Hospital
Kurashiki Central Hospital
Kurashiki Heisei Hospital
Kurosawa Hospital
Kurosishi General Hospital
Kurosu Hospital
Kurume University Hospital

Kyorin University Hospital
Kyoritsu Hospital
Kyoto Okamoto Memorial Hospital
Kyoto Second Red Cross Hospital
Kyoto Univerisity Hospital
Kyoto Yamashiro General Medical Center
Kyotokatsura Hospital
Kyotomin-Iren Chuohospital
Kyushu Central Hospital of The Mutual Aid Association of Public
School Teachers
Kyushu Rosai Hospital

Takuya Kawai
Mitsuyuki Fujitsuka
Akira Takada, Seiji Tajiri
Masaki Chin
Hidemiti Sasayama
Sigehiro Ohmori
Seiko Hasegawa
Kazuhiro Kikuchi, Mikio Teduka
Motohiro Morioka
Yoshiko Unno, Hiroki Yoshida , Teruyuki
Hirano
Masayuki Yokota
Minoru Kidooka
Hiroshi Tenjin
Susumu Miyamoto
Yoshihiro Iwamoto
Yasumasa Yamamoto
Yuko Shikata

Hitonori Takaba
Sei Haga



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5	Kyushu University Hospital	Koji Iihara
6	Local Incorporated Administrative Agency Tokushima Prefecture	
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8	Naruto Hospital	Masahito Agawa
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10	Makita General Hospital	Yoshinori Arai
11		
12	Maruko Central Hospital	Toshiyuki Tsukada
13		
14	Matsushita Memorial Hospital	Nozomu Murai
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16	Matsuyama Shimin Hospital	Masakazu Suga
17		
18	Mazda Hospital	Kawamoto Yukihiro
19		
20	Medical Corporation Ijinkai Nakamura Memorial Hospital	Kenji Kamiyama
21		
22	Medical Corporation Meiseikai Abashiri Neurosurgicalrehabilitation Hospital	Naoto Izumi
23		
24	Meitetsu Hospital	Youtarou Takeuchi
25		
26	Midorigaoka Hospital	Motohiro Arai
27		
28	Mie University Hospital	Hidenori Suzuki
29		
30	Mimihara General Hospital	Shinji Okumura
31		
32	Minamata City General Hospital and Medical Center	Makoto Yoshikawa
33		
34	Minami Wakayama Medical Center	Yoshinari Nakamura
35		
36	Minato Medical Coop-Kyoritsu General Hospital	Hisashi Tanaka
37		
38	Mito Kyodo General Hospital	Yasusi Sibata
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40	Mitoyogeneralhospital	Tetsuya Masaoka
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42	Mitsugi General Hospital	Takashi Matsuoka
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Miyakonojo Medical Association Hospital

Hajime Ohta

Miyoshi Central Hospital

Osamu Hamasaki

Moriguchi-Ikuno Memorial Hospital

Misao Nishikawa

Morioka Red Cross Hospital

Naohiko Kubo

Munakata Suikokai General Hospital

Yosimasa Kinoshita

Muroran City General Hospital

Hiroshi Ooyama

Nagahama City Hospital

Taro Komuro

Nagano Municipal Hospital

Yoshikazu Kusano

Nagaoka Chuo General Hospital

Shigekazu Takeuchi

Nagasaki Kawatana Medical Center

Ei-Ichirou Urasaki

Nagasaki University Hospital

Takayuki Matsuo

Nagasaki Shimabara Hospital

Yoshiharu Tokunaga

Nagoya City University

Mitsuhiro Mase

Nagoya Daini Red Cross Hospital

Yukio Seki, Keizo Yasui

Nagoya University Hospital

Yoshio Araki

Naha City Hospital

Naoki Tomiyama

Nakamura Memorial South Hospital

Taiichiro Watanabe, Koji Oka

Nakatsu Municipal Hospital

Hiromichi Koga

Nara Medical University

Hiroyuki Nakase

Narita Red Cross Hospital

Michio Nakamura

National Cerebral and Cardiovascular Center

Jun Takahashi

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5	National Hospital Organization Chiba Medical Center	Hirokazu Tanno
6	National Hospital Organization Hamada Medical Center	Takato Kagawa
7		
8	National Hospital Organization Himeji Medical Center	Osamu Narumi
9		
10	National Hospital Organization Kyushu Medical Center	Akira Nakamizo, Shinji Nagata
11	National Hospital Organization Nagoya Medical Center	Noriyuki Suzaki
12		
13	National Hospital Organization Okayama Medical Center	Yoichiro Namba
14		
15	National Hospital Organization Osakaminami Medical Center	Tomonori Yamada
16	National Hospital Organization Tochigi Medical Center	Masayuki Ishihara
17		
18	National Hospital Organization Toyohashi Medical Center	Hideki Sakai
19		
20	National Hospital Organization Ureshino Medical Center	Masayuki Miyazono
21	National Hospital Organization, Iwakuni Clinical Center	Kotaro Ogihara
22		
23	Nayoro City Hospital	Naoki Tokumitsu
24		
25	Nho Sendai Medical Center	Masayuki Ezura
26		
27	Nho Shinshu Ueda Medical Center	Keiichi Sakai
28		
29	Nihon University Itabashi Hospital	Atsuo Yoshino
30	Niigata City General Hospital	Kenichi Morita, Akihiko Saito
31		
32	Niigata Prefectural Central Hospital	Igarashi Michitoku
33		
34	Niigata Tokamachi Hospital	Mitsuo Kouno
35	Niigata University Medical and Dental Hospital	Yukihiko Fujii, Osamu Onodera
36		
37	Niigatanougekabyouin	Kiyoshi Onda
38	Nishikobe Medical Center	Naoya Takeda
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Nishinomiya Kyoritsu Neurosurgical Hospital	Hiroji Miyake
Nishio Municipal Hospital	Toshio Yokoe
Nishitokyo Central General Hospital	Tatsuya Nakamura
Nissan Tamagawa Hospital	Takayuki Kubodera
Nitobe Memorial Nakano General Hospital	Mitsuhiro Hokari
Noshiro Kosei Medical Center	Yasunari Otawara
Noto General Hospital	Cheho Park
Nozaki Tokushukai Hospital	Hidemitsu Nakagawa
Obara Hospital	Souichi Obara
Obase Hospital	Haruki Takahashi
Obihiro Kosei General Hospital	Masafumi Ohtaki
Odate Municipal General Hospital	Atsuya Okubo
Ogaki Tokushukai Hospital	Katsuhiko Hayashi
Ohnishi Neurological Center	Hideyuki Ohnishi, Yoshihiro Kuga
Ohta Nishinouchi Hospital	Masahisa Kawakami
Oita Prefectural Hospital	Yu Takeda
Oitaken Koseiren Tsurumi Hospital	Akihiko Kaga
Okaya City Hospital	Ryoichi Hayashi
Okayama City Hospital	Koji Tokunaga
Okayama Kyokuto Hospital	Hiroyuki Nakashima
Okayama University Hospital	Isao Date

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5	Okinawa Kyodo Hospital	Koji Idomari, Nobuyuki Kaneko
6	Okinawa Prefectural Nanbu Medical Center and Children's Medical	
7	Center	Tomoaki Naganine
8		
9	Okitama Public General Hospital	Toshihiko Kinjo
10		
11	Ome Municipal General Hospital	Yoshiaki Takada, Osamu Tao
12		
13	Omihachiman Community Medical Center	Masayuki Nakajima
14		
15	Omori Red Cross Hospital	Akira Isoshima
16		
17	Omuta City Hospital	Terukazu Kuramoto
18		
19	Onomichi Municipal Hospital	Shigeru Daido
20		
21	Osaka Medical College	Toshihiko Kuroiwa
22		
23	Osaka National Hospital	Kazuo Hashikawa
24		
25	Osaka Neurological Institute	Akatsuki Wakayama
26		
27	Osaka Neurosurgical Hospital	Naoki Hayashi
28		
29	Osaka University Hospital	Kouich Iwatsuki, Toshiki Yoshimine
30		
31	Osaki Citizen Hospital	Masahiro Yoshida
32		
33	Otaru General Hospital	Yoshimasa Niiya
34		
35	Otsu City Hospital	Motohiro Takayama
36		
37	Otsu Red Cross Hospital	Masaaki Saiki
38		
39	Rakuwakaiotowa Hospital	Kazuo Yamamoto
40		
41	Research Institute For Brain and Blood Vessels-Akita	Junta Moroi, Taizen Nakase, Tatsuya Ishikawa
42		
43	Saga-Ken Medical Centre Koseikan	Shuji Sakata, Hiroshi Sugimori
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Saiseikai Futsukaichi Hospital

Naoko Fujimura

Saiseikai Imabari Hospital

Osamu Nishizaki

Saiseikai Kumamoto Hospital

Toru Nishi

Saiseikai Kurihashi Hospital

Hiroshi Wanihuti

Saiseikai Kyoto Hospital

Nobukuni Murakami

Saiseikai Matsusaka General Hospital

Hiroto Murata

Saiseikai Nagasaki Hospital

Wataru Haraguchi

Saiseikai Toyama Hospital

Yukio Horie

Saiseikai Yahata General Hospital

Yuji Okamoto

Saiseikai Yokohamashi Tobu Hospital

Makoto Inaba

Saiseikaiustunomiya Hospital

Masashi Nakatsukasa

Saitama City Hospital

Atsuhiko Kojima

Saitama Medical Center

Kyoichi Nomura

Saitama Red Cross Hosoiat

Toshie, Yamamoto Kenji Takahashi

Sakai City Medical Center

Yoshikazu Nakajima

Saku Central Hospital Advanced Care Center

Takaaki Yoshida

Sanyudohospital

Yohei Kudoh

Sapporo Azabu Neurosurgical Hospital

Toshitaka Nakamura

Sapporo Medical University Hospital

Nobuhiro Mikuni

Sapporo Shiroishi Memorial Hospital

Akira Takahashi

Sapporoteishinkaihospital

Rokuya Tanikawa

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5	Sasebo Chuo Hospital	Seisaburo Sakamoto
6	Secomedic Hospital	Seichiro Hoshi
7		
8	Seikeikai Hospital	Yoshinari Okumura
9		
10	Seirei Memorial Hospital	Sinichi Okabe
11	Seirei Mikatahara General Hospital	Haruhiko Sato
12		
13	Sendai City Hospital	Hiroshi Karibe
14		
15	Shakaiiryuhoujinzaidanshinwakaiyachiyobyuin	Takashi Inoue
16	Shikoku Medical Center For Children and Adults	Kazuyuki Kuwayama
17		
18	Shimane Prefectural Central Hospital	Tatsuya Mizoue
19		
20	Shimizu Hospital	Takashi Yoshida
21	Shimonoseki City Hospital	Takaharu Nakamura
22		
23	Shin Koga Hospital	Tsutomu Hitotsumatsu
24		
25	Shin-Oyama City Hospital	Tomoaki Kameda
26	Shingu Municipal Medical Center	Mitsukazu Nakai, Hiroshi Ishiguchi
27		
28	Shinonoi General Hosapital	Masanobu Hokama
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30	Shinsapporo Neurosurgical Hospital	Akinori Yamamura
31	Shinshu University Hospital	Kazuhiro Hongo
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33	Shinsuma General Hospital	Takeshi Kondoh
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35	Shintakeohospital	Makoto Ichinose
36	Shizuoka Children's Hospital	Yuzuru Tashiro
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38	Shizuoka City Shizuoka Hospital	Seiji Fukazawa
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Shonan Kamakura General Hospital	Takahisa Mori
Showa Inan General Hospital	Shinsuke Muraoka
Showa University Fujigaoka Hospital	Tomoaki Terada
Shuuwa General Hospital	Tsuneo Shishido
Social Welfare Organization Saiseikai Imperial Gift Foundation Inc.	
Osaka Saiseikai Ibaraki Hospital	Yasunobu Gotou
Social Welfare Organization Saiseikai Imperial Gift Foundation Inc. Yamagata Saisei	Sunao Takemura
South Miyagi Medical Center	Hiroaki Arai
Southern Tohoku Hospital	Zenichiro Watanabe
St. Marianna University School of Medicine	Yuichiro Tanaka
St.Luke's International Hospital	Yasunari Niimi
Steel Memorial Yawata Hospital	Shinya Yamaguchi, Akira Nakamizo
Suiseikai Kajikawa Hospital	Shinichi Wakabayashi
Suwa Central Hospital	Hiroki Sato
Suwa Red Cross Hospital	Yukinari Kakizawa
Syakaiiryohouzin Kouseikai Takai Hospital	Tetsuya Morimoto
Tachibana Medical Corporation Higashisumiyoshi Morimoto Hospital	Naofumi Isono
Tachikawa General Hospital	Hiroki Takano, Hiroshi Abe
Takamatsu Municipal Hospital	Norihito Shirakawa
Takamatsu Red Cross Hospital	Masahiro Kagawa

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5	Takarazuka City Hospital	Eiichiro Mabuchi
6	Takarazuka Daiichi Hospital	-
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8	Takatsuki General Hospital	Kazusige Maeno
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10	Takeda General Hospital Organization	Takayuki Koizmi
11	Takeda Hospital	Waro Taki
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13	Takikawa Neurosurgical Hospital	Yusuke Nakagaki
14		
15	Tanushimaru Central Hospital	Yoshihisa Matumoto
16	Teinekeijinkai Hospital	Katuyuki Asaoka
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18	Tenri Hospital	Yoshinori Akiyama
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20	Tenshindo Hetsugi Hospital	Tadao Kawamura
21	Teraoka Memorial Hospital	Atumi Takenobu
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23	The Veritas Hospital	Masayuki Yokota
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25	Tobata Kyoritu Hospital	Taketoshi Tuji
26	Tohoku University Hospital	Teiji Tominaga
27		
28	Tokai University Hachioji Hospital	Shigeru Nogawa, Masami Shimoda
29		
30	Toki General Hospital	Sinji Noda
31	Tokushima Red Cross Hospital	Hajimu Miyake
32		
33	Tokushima University Hospital	Shinji Nagahiro, Junichiro Satomi
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35	Tokuyama Central Hospital	Kunihiko Harada
36	Tokyo Dental College Ichikawa General Hospital	Sadao Suga
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38	Tokyo General Hospital	Shinichi Numazawa
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Tokyo Medical and Dental University	Taketoshi Maehara
Tokyo Medical University Hachioji Medical Center	Hiroyuki Jimbo, Jyunya Tsurukiri
Tokyo Medical University Hospital	Michihiro Kohno
Tokyo Metropolitan Hiroo Hospital	Kensaku Yoshida
Tokyo Metropolitan Geriatric Hospital and Institute of Gerontology	Koji Matuoka
Tokyo Metropolitan Tama Medical Center	Takahiro Ota
Tokyo Saiseikai Central Hospital	Haruhiko Hoshino
Tokyo Teisin Hospital	Makoto Noguchi
Tokyo Women's Medical University	Takakazu Kawamata
Tokyo Yamate Medical Center	Yasuaki Takeda
Tomakomaihigashi Hospital	Youichi Hashimoto
Tomei Atsugi Hopital	Keiichirou Onitsuka
Tominaga Hospital	Masahiko Kitano
Tomishiro Central Hospital	Jae-Hyun Son
Tottori Municipal Hospital	Keiichi Akatsuka
Tottori University	Masamichi Kurosaki, Takashi Watanabe
Toyama City Hospital	Miyamori Tadao
Toyama Prefectural Central Hospital	Hiroaki Hondo
Toyama Red Cross Hospital	Kazumasa Yamatani, Kotaro Tsumura
Toyama University Hospital	Satoshi Kuroda
Toyohashi Municipal Hospital	Hirofumi Oyama

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5	Toyokawa City Hospital	Takayuki Watanabe
6	Toyooka Hospital	Kazuhiro Tanaka
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8	Tsuchiura Kyodo General Hospital	Shinji Yamamoto
9		
10	Tsukuba Medical Center Hospital	Kazuya Uemura
11	Tsuruoka Municipal Shonai Hospital	Hirosi Maruya, Kazuhiko Sato
12		
13	Tsutiura Kyodo Hospital Namegata District Medical Center	Hitoshi Tabata
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15	Tsuyama Chuo Hospital	Hideyuki Yoshida
16	Tyuubu Rousai Hospital	Noriaki Matubara
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18	Ube Kohsan Industries Hospital	Takafumi Nishizaki
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20	Uki General Hospital	Hiroshi Egami
21	University of Fukui Hospital	Osamu Yamamura
22		
23	University of Occupational and Environmental Health	Junkoh Yamamoto
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25	University of The Ryukyus Hospital	Shogo Ishiuchi
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27		Yuji Matsumaru, Akira Matsumura, Tetsuya
28	University of Tsukuba Hospital	Yamamoto
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30	University of Yamanashi	Hiroyuki Kinouchi
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32	Urasoe General Hospital	Susumu Mearu
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34	Ushioda General Hospital	Hitoshi Ozawa
35	Uwajima City Hospital	Kiichiro Zenke
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37	Wakayama Medical University Hospital	Naoyuki Nakao
38	Wakayama Rosai Hospital	Toshikazu Kuwata
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Wakayama-Seikyo Hospital	Teruyuki Habu
Yaizu City Hospital	Seiya Takehara
Yamagata City Hospital Saiseikan	Rei Kondo
Yamagata Prefectural Central Hospital	Takashi Kumagai
Yamagata Prefectural Shinjo Hospital	Keiten So
Yamagata University Hospital	Yukihiko Sonoda
Yamaguchi Prefectural Grand Medical Center	Manabu Urakawa
Yamaguchi Red Cross Hospital	Yasuhiro Hamada
Yamaguchi University Hospital	Michiyasu Suzuki
Yamanashi Prefectural Central Hospital	Shin Nakano, Hidehito Koizumi
Yamanashi Redcross Hospital	Hiroshi Ozawa
Yamanashikouseibyuin	Mikito Uchida
Yamato Municipal Hospital	Masaru Yamada
Yao Tokushukai General Hospital	Takashi Turuno
Yatsuo General Hospital	Ryouichi Masuda
Yawata Medical Center	Makoto Kimura
Yayoigaoka Kage Hospital	Shin-Ichiro Ishihara
Yodogawa Christian Hospital	Masashi Morikawa
Yokohama City Minato Red Cross Hospital	Yasunori Takemoto, Hiroaki Tanaka
Yokohama City University Hospital	Hidetoshi Murata, Nobutaka Kawahara
Yokohama City University Medical Center	Katsumi Sakata

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Endo Sumio

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Tooru Sasaki

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Yasuhisa Yoshida

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10 Yuaikaihospital

Yoshihumi Teramoto

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	3
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6,7
Bias	9	Describe any efforts to address potential sources of bias	11
Study size	10	Explain how the study size was arrived at	8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	10
		(d) If applicable, describe analytical methods taking account of sampling strategy	-
		(e) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	11
		(b) Give reasons for non-participation at each stage	14
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-14
		(b) Indicate number of participants with missing data for each variable of interest	14
Outcome data	15*	Report numbers of outcome events or summary measures	11-14
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	11-13

		which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	11-13
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	11-13
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13,14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.