interventions and unique aspects of comprehensive stroke care capacity in Japan.

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Appendix Table 1. *List of the responding hospitals*

Abashiri Neurosurgical Rehabilitation Hospital
Ageo Central General Hospital
Aichi Medical University Hospital
Aidu Chuo Hospital
Aizawa Hospital
Akiba Hospital
Akiru Municipal Medical Center
Akita General Hospital
Akita Kumiai General Hospital
Akita Rosai Hospital
Akita University Hospital
Ako Central Hospital
Ako City Hospital
Almeida Memorial Hospital
Amakusa Medical Center
Anji Kosei Hospital
Aomori Kyoritsu Hospital
Aomori Municipal Hospital
Aomori Rosai Hospital
Aoyama Hospital
Araki Neurosurgical Hospital
Arao City Hospital
Arita Kyouritsu Hospital
Asahikawa Medical University Hospital
Asahikawa Red Cross Hospital
Asao General Hospital
Ashikaga Red Cross Hospital
Atsumi Hospital
Ayabe City Hospital
Azuma Neurosurgical Hospital
Azumi General Hospital
Azumino Red Cross Hospital
Baba Memorial Hospital
Bellland General Hospital
Beppu Medical Center, National Hospital Organization
Bizen Municipal Hospital
Central Gunma Neurosurgical Hospital
Chiba Cardiovascular Center
Chiba Central Medical Center
Chiba Emergency Medical Center
Chiba Neurosurgical Clinic
Chiba University Hospital
Chichibu City Hospital
Chigasaki City Hospital
Chikamori Hospital
Chubu-Tokusyukai Hospital
Chugoku Rousai Hospital
Chuno Kosei Hospital
Daiichi Hospital
Daini Okamoto General Hospital
Daiwa Hospital
Dohtoh Neurosurgical Hospital
Dokkyo Medical University Hospital
Ehime Prefectural Central Hospital
Ehime Prefectural Imabari Hospital
Ehime University Hospital
Enshu Hospital
Fuchu Hospital

(*Continued*)

Appendix Table 1. *(Continued)*

Fuji Brain Institute and Hospital
Fuji City General Hospital
Fujii Neurosurgical Hospital
Fujimoto Hayasuzu Hospital
Fujisawa City Hospital
Fujisawa Neurosurgical Hospital
Fujita General Hospital
Fujita Health University Hospital
Fujiyoshida Municipal Medical Center
Fukaya Red Cross Hospital
Fukui Red Cross Hospital
Fukui General Hospital
Fukui Kosei Hospital
Fukui Social Insurance Hospital
Fukui University Hospital
Fukuoka City Hospital
Fukuoka Kieikai Hospital
Fukuoka Seishukai Hospital
Fukuoka Shin Mizumaki Hospital
Fukuoka Tokushukai Medical Center
Fukuoka University Hospital
Fukuroi Municipal Hospital
Fukushima Medical University Hospital
Fukushima Prefectural Aizu General Hospital
Fukushima Red Cross Hospital
Fukushima Takanori Memorial Hospital
Furukawa Seiryo Hospital
Fussa Hospital
Gamagohri City Hospital
Geriatrics Research Institute and Hospital
Gifu Central Hospital
Gifu Municipal Hospital
Gifu Prefectural General Medical Center
Gifu Prefectural Tajimi Hospital
Gifu University Hospital
Goshi Hospital
Gunma University Hospital
Hachinohe Heiwa Hospital
Hachisuga Hospital
Hakodate Neurosurgical Hospital
Hakodate Shintoshi Hospital
Hakuai Hospital
Hakuo-kai Sumi Hospital
Hamamatsu Medical Center
Hamamatsu University School of Medicine, University Hospital
Hamamatu Rosai Hospital
Hamanomachi Hospital
Hanwa Memorial Hospital
Harada Hospital
Hashima City Hospital
Hata Kenmin Hospital
Hayashi Hospital
Health Insurance Amakusa Chuo General Hospital
Health Insurance Nankai Hospital
Health Insurance Naruto Hospital
Heart Life Hospital
Heisei Memorial Hospital

(*Continued*)

Appendix Table 1. *(Continued)*

Heisei Neurosurgical Hospital
Hibino Hospital
Hidaka General Hospital
Higashimatsuyama Medical Association Hospital
Higashiyamato Hospital
Hikone Municipal Hospital
Himeji Central Hospital
Himi Municipal Hospital
Hiratsuka City Hospital
Hirosaki University Hospital
Hiroshima City Asa Hospital
Hiroshima General Hospital
Hiroshima Prefectural Hospital
Hiroshima Red Cross Hospital and Atomic-bomb Survivors Hospital
Hiroshima University Hospital
Hokkaido Neurosurgical Memorial Hospital
Hokkaido University Hospital
Hokushin General Hospital Nagano Prifectural Fideration of Agricultural Cooperatives for Health and Welfare
Hokushinkai Megumono Hospital
Hokuto Hospital
Hoshigaoka Koseinenkin Hospital
Houetsu Hospital
Hskinan Municipal Hospital
Hyogo Brain and Heart Center
Hyogo Prefectural Amagasaki Hospital
Hyogo Prefectural Awaji Hospital
Hyogo Prefectural Nishinomiya Hospital
Ibaraki Prefectural Central Hospital
Ibaraki Seinan Medical Center Hospital
Ibi Kousei Hospital
Ichinomiya Neurosurgery Hospital
Ichinomiya West Hospital
Ichinose Hospital
Iida Municipal Hospital
Iizuka Hospital
Ikeda Neurosurgical Center Hospital
Ikuwakai Memorial Hospital
Imakiire General Hospital
Imamura Bun-in Hospital
Inagi Municipal Hospital
International University of Health and Welfare ATAMI HOSPITAL
Inuyama Chuo Hospital
Iseikai Hospital
Iseikai Yahata Central Hospital
Isesaki Municipal Hospital
Ishikawa Prefectural Central Hospital
Ishinkai Yao General Hospital
Ishinomaki City Hospital
Ishioka Dai-Ichi Hospital
Isogo Central Hospital
Itami Kousei Neurosurgical Hospital
Itoigawa General Hospital
Itsukaichi Memorial Hospital
Iwaki Kyoritsu Hospital
Iwamizawa Municipal General Hospital

(Continued)

Appendix Table 1. *(Continued)*

Iwata City Hospital
Iwate Medical University Hospital
Iwate Prefectural Iwai Hospital
Iwate Prefectural Ninohe Hospital
Iwate Prefecturel Isawa Hospital
Izumi General Medical Center
Izumino Hospital
Izumu Municipal Hospital
JA Kochi Hospital
JA Toride Medical Center
Japan Medical Alliance Higashi Saitama General Hospital
Japanese Red Cross Hadano Hospital
Japanese Red Cross Kitami Hospital
Japanese Red Cross Kobe Hospital
Japanese Red Cross Kochi Hospital
Japanese Red Cross Koga Hospital
Japanese Red Cross Kyoto Daini Hospital
Japanese Red Cross Medical Center
Japanese Red Cross Nagasaki Genbaku Hospital
Japanese Red Cross Ogawa Hospital
Japanese Red Cross Society Hachinohe Medical Center
Japanese Red Cross Society Himeji Hospital
Jiaikai Kajiura Hospital
Jichi Medical University Hospital
JR Tokyo General Hospital
Junshin Hospital
Juntendo University Hospital
Juntendo University Nerima Hospital
Juntendo University Urayasu Hospital
Junwakai Kinen Hospital
Juzenkai Hospital
Jyuzen General Hospital
Kaga City Hospital
Kagawa Prefectural Central Hospital
Kagawa Rosai Hospital
Kagawa University Hospital
Kagoshima City Hospital
Kagoshima prefectural Oshima Hospital
Kagoshima Tokushukai Hospital
Kagoshima University Medical and Dental Hospital
Kainan Hospital
Kaiseikai Onishi Hospital
Kakegawa Municipal General Hospital
Kakizoe Hospital
Kakogawa City Hospital
Kameda Medical Center
Kameoka Shimizu Hospital
Kamiichi General Hospital
Kamitsuga General Hospital
Kanazawa Medical University Hospital
Kanazawa Municipal Hospital
Kanazawa Neurosurgical Hospital
Kanazawa University Hospital
Kanetsu Hospital
Kanoya Medical Center
Kansai Medical University Takii Hospital
Kanto Central Hospital for Public School Teachers
Kantoh Neurosurgical Hospital

(Continued)

Appendix Table 1. *(Continued)*

Karatsu Red Cross Hospital
Kariya Toyota General Hospital
Kasai Cardiology Neurosurgery Hospital
Kasaoka Daiichi Hospital
Kashima Rosai Hospital
Kashiwaba Neurosurgical Hospital
Kashiwazaki General Hospital and Medical Center
Kasugai Municipal Hospital
Kasukabe Chuo General Hospital
Katagi Neurosurgical Hospital
Katano Hospital
Katsuta Hospital
Kawachi General Hospital
Kawakita General Hospital
Kawano Neurosurgical Hospital
Kawasaki Hospital
Kawasaki Medical School Hospital
Kawasaki municipal Hospital
Kawasaki Municipal Tama Hospital
Kawasakisaiwai Hospital
Kazuno Kosei Hospital
Keijin Kai Kawasaki Hospital
Keiwakai Ebetsu Hospital
Kenwakai Otemachi Hospital
Kimitsu Chuo Hospital
Kinan Hospital
Kinki University Hospital
Kiryuu Kohsei General Hospital
Kishiwada Tokushukai Hospital
Kitakyushu Municipal Medical Center
Kitamurayama Hospital
Kitano Hospital
Kizawa Memorial Hospital
KKR Sapporo Medical Center
Kobari General Hospital
Kobe University Hospital
Kochi Health Sciences Center
Kochi Medical School Hospital
Kofu Jonan Hospital
Kofu Municipal Hospital
Kofu Neurosurgical Hospital
Kohka Public Hospital
Kohnan Hospital
Kokubu Neurosurgical Clinic
Kokura Memorial Hospital
Komaki City Hospital
Komatsu Municipal Hospital
Komono Kosei Hospital
Konan Kosei Hospital
Konan Tobu General Hospital
Kosei Hospital
Koshigaya Municipal Hospital
Koto Memorial Hospital
Kousei General Hospital
Kouseikai Takai Hospital
Kouseiren Murakami Hospital
Kugayama Hospital
Kumamoto City Hospital

(Continued)

Appendix Table 1. *(Continued)*

Kumamoto Red Cross Hospital
Kumamoto Rousai Hospital
Kumamoto Takumadai Hospital
Kumamoto University Hospital
Kurashiki Central Hospital
Kurashiki Heisei Hospital
Kure Kyosai Hospital
Kurobe City Hospital
Kuroishi City Hospital
Kurosawa Hospital
Kurosu Hospital
Kurume University Hospital
Kusatsu General Hospital
Kushiro Kojinkai Memorial Hospital
Kushiro Rosai Hospital
Kuwana Hospital
Kuwana West Medical Center
Kyorin University Hospital
Kyoritsu General Hospital
Kyosai Tachikawa Hospital
Kyoto City Hospital
Kyoto Kujo Hospital
Kyoto Min-iren Chuo Hospital
Kyushu University Hospital
Machida Municipal Hospital
Maebashi Red Cross Hospital
Makita General Hospital
Masu Memorial Hospital
Matsudo City Hospital
Matsunami General Hospital
Matsushita Memorial Hospital
Matsuyama Red Cross Hospital
Matsuyama Shimin Hospital
Mattoh-Ishikawa Central Hospital
Mazda Hospital
Medical Corporation Kawamura Society Kubokawa Hospital
Meisei Hospital
Meitetsu Hospital
Midorigaoka Hospital
Mie Prefectural General Medical Center
Mie University Hospital
Mihara Memorial Hospital
Minamata City General Hospital and Medical Center
Minamisoma City General Hospital
Minase Hospital
Mine City Hospital
Minei Daiichi Hospital
Mino Municipal Hospital
Minoh City Hospital
Mishuku Hospital
Mishuku Hospital
Mito Medical Center
Mito Saiseikai General Hospital
Mitoyo General Hospital
Mitsugi General Hospital
Miyakonojo Regional Medical Center
Miyoshi Central Hospital

(Continued)

Appendix Table 1. *(Continued)*

Mizushima Central Hospital
Morioka JRC Hospital
Moriya-daiichi General Hospital
Murakami Memorial Hospital Asahi University
Murata Hospital
Muroran City General Hospital
Musashino General Hospital
Nadogaya Hospital
Naga District Hospital
Nagahama City Hospital
Nagahama Red Cross Hospital
Nagano Municipal Hospital
Nagano Prefectural Kiso Hospital
Nagano Prefectural Suzaka Hospital
Nagano Red Cross Hospital
Nagaoka Chuo General Hospital
Nagaoka Red Cross Hospital
Nagareyama Central Hospital
Nagasaki Kawatana Medical Center
Nagasaki Municipal Hospital
Nagasaki Prefecture Shimabara Hospital
Nagasaki University Hospital
Nagatomi Neurosurgical Hospital
Nagoya Daini Red Cross Hospital
Nagoya Ekisaikai Hospital
Nagoya Medical Center
Nagoya Memorial Hospital
Nagoya University Hospital
Naha City Hospital
Nakamura Memorial Hospital
Nakamura Memorial South Hospital
Nakano General Hospital
Nakatsu Gastrointestinal Hospital
Namegata District General Hospital
Nanbu Tokushukai Hospital
Nantan General Hospital
Nantan General Hospital
Nara City Hospital
Nara Medical University Hospital
Nara Prefectural Hospital
Nara Prefectural Mimuro Hospital
Narita Red Cross Hospital
Nasu Neurosurgical Hospital
Nasu Red Cross Hospital
National Cancer Center Hospital
National Center for Child Health and Development
National Center for Global Health and Medicine
National Cerebral and Cardiovascular Center
National Disaster Medical Center
National Fukuoka-Higashi Medical Center
National Hospital Organization Chiba Medical Center
National Hospital Organization Hamada Medical Center
National Hospital Organization Himeji Medical Center
National Hospital Organization Kanazawa Medical Center
National Hospital Organization Kanmon Medical Center
National Hospital Organization Kobe Medical Center

(Continued)

Appendix Table 1. *(Continued)*

National Hospital Organization Kumamoto Medical Center
National Hospital Organization Kure Medical Center
National Hospital Organization Maizuru Medical Center
National Hospital Organization Minami Wakayama Medical Center
National Hospital Organization Nagasaki Medical Center
National Hospital Organization Nara Medical Center
National Hospital Organization Okayama Medical Center
National Hospital Organization Osaka Minami Medical Center
National Hospital Organization Saitama National Hospital
National Hospital Organization Shizuoka Medical Center
National Hospital Organization Takasaki General Medical Center
National Hospital Organization Ureshino Medical Center
National Hospital Organization Utano Hospital
National Hospital Organization Yokohama Medical Center
National Kyushu Medical Center
Nayoro City General Hospital
Nihon University Itabashi Hospital
Niigata City General Hospital
Niigata Minami Hospital
Niigata Neurosurgical Hospital and Brain Research Center
Niigata Prefectural Cancer Center Hospital
Niigata Prefectural Central Hospital
Niigata Prefectural Shibata Hospital
Niigata Prefectural Tokamachi Hospital
Niigata Rosai Hospital
Niigata University Medical and Dental Hospital
Nippon Medical School Chiba Hokusoh Hospital
Nippon Medical School Hospital
Nippon Medical School Musashi Kosugi Hospital
Nippon Medical School Tama-Nagayama Hospital
Nipponbashi Hospital
Nishi-Agatsuma Welfare Hospital
Nishi-Kobe Medical Center
Nishinara Tyuou Hospital
Nishinomiya Kyoritsu Neurosurgical Hospital
Nishio Municipal Hospital
Nishisaitama-chuo National Hospital
Nishiwaki Municipal Hospital
North Fukushima Medical Center
North Osaka Police Hospital
NTT Medical Center Tokyo
Obara Hospital
Obihiro-Kosei General Hospital
Odate Municipal General Hospital
Odawara Municipal Hospital
Oe Kyodou Hospital
Ofunato Hospital
Ogachi Central Hospital
Ogaki Municipal Hospital
Ogori Daiichi General Hospital

(Continued)

Appendix Table 1. *(Continued)*

Ohda Municipal Hospital
Ohkawara Neurosurgical Hospital
Ohmiya Chuo General Hospital
Ohnishi Neurological Center
Ohta General Hospital
Oita Prefectural Hospital
Oita University Hospital
Oita-Oka-Hospital
Okayama City Hospital
Okayama East Neurosurgical Clinic
Okayama Kyokuto Hospital
Okayama Kyoritsu General Hospital
Okayama Rosai Hospital
Okayama University Hospital
Okazaki City Hospital
Okinawa Chubu Hospital
Okinawa Hokubu Hospital
Okinawa Kyodo Hospital
Okinawa Prefectural Miyako Hospital
Okinawa Prefectural Nanbu Medical Center and Children's Medical Center
Okinawa Prefectural Yaeyama Hospital
Okitama Public General Hospital
Okyama East Neurosurgical clinic
Omihachiman Community Medical Center
Omori Red Cross Hospital
Omuta City Hospital
Ooi-Byouin
Ookuma Hospital
Ota Memorial Hospital
Osaka City General Hospital
Osaka City University Hospital
Osaka General Medical Center
Osaka Kosei-Nenkin Hospital
Osaka Medical Center
Osaka Medical College Hospital
Osaka Mishima Critical Care Medical Center
Osaka Neurological Institute
Osaka Neurosurgical Hospital
Osaka Police Hospital
Osaka Prefectural Senshu Critical Care Medical Center
Osaka Red Cross Hospital
Osaka Rosai Hospital
Osaka University Hospital
Otemae Hospital
Otsu Municipal Hospital
Research Institute for Brain and Blood Vessels Akita
Rumoi Central Clinic
Sadamoto Hospital
Saga Prefectural Hospital Koseikan
Saga Social Insurance Hospital
Sagamihara Kyodo Hospital
Sagamihara–chuo Hospital
Saisei-kai Yokohama-shi Nanbu Hospital
Saiseikai Central Hospital
Saiseikai Fukuoka General Hospital
Saiseikai Gose Hospital
Saiseikai Hita Hospital

(Continued)

Appendix Table 1. *(Continued)*

Saiseikai Hyuga Hospital
Saiseikai Imabari Hospital
Saiseikai Kumamoto Hospital
Saiseikai Kurihashi Hospital
Saiseikai Kyoto Hospital
Saiseikai Matsusaka General Hospital
Saiseikai Matsuyama Hospital
Saiseikai Nagasaki Hospital
Saiseikai Nakatsu Hospital
Saiseikai Nara Hospital
Saiseikai Noe Hospital
Saiseikai Saijo Hospital
Saiseikai Shimonoseki General Hospital
Saiseikai Toyama Hospital
Saiseikai Utsunomiya Hospital
Saiseikai Yahata General Hospital
Saiseikai Yamaguchi Hospital
Saiseikai Yokohanashi Tobu Hospital
Saiseikai-Chuwa Hospital
Saitama Cancer Center Hospital
Saitama Cardiovascular and Respiratory Center
Saitama Medical Center
Saitama Medical Center Jichi Medical University
Saitama Medical University Hospital
Saitama Medical University International Medical Center
Saitama Municipal Hospital
Saito Memorial Hospital
Sakai City Hospital
Sakai Hospital Kinki University Faculty of Medicine
Sakaide Municipal General Hospital
Saku Central Hospital
Sakura General Hospital
Sakurakai Hospital
Sanda City Hospital
Sankoukai Miyazaki Hospital
Sannocho Hospital
Sano Kousei General Hospital
Sanyudo Hospital
Sapporo City General Hospital
Sapporo Higashi-Tokushukai Hospital
Sasebo Chuo Hospital
Sasebo City General Hospital
Sayama Hospital
Seguchi Neurosurgery Hospital
Seirei Hamamatsu General Hospital
Seirei Memorial Hospital
Seirei Mikatagahara General Hospital
Seirei Yokohama Hospital
Seiyu Memorial Hospital
Sendai City Hospital
Sendai Medical Association Hospital
Sendai Open Hospital
Senpo Tokyo Takanawa Hospital
Senseki Hospital
Shakaihoken Kobe Central Hospital
Shakaihoken Shimonoseki Kosei Hospital
Shiga Medical Center for Adults
Shiga University of Medical Science Hospital

(Continued)

Appendix Table 1. *(Continued)*

Shimada City Hospital
Shimane Prefectural Central Hospital
Shimane University Hospital
Shimonoseki City Hospital
Shimotsuga General Hospital
Shin Koga Hospital
Shin Yukuhashi Hospital
Shin-Tokyo Hospital
Shingu Municipal Medical Center
Shinko Hospital
Shinoda General Hospital
Shinonoi General Hospital
Shinrakuen Hospital
Shinseikai Toyama Hospital
Shinshu Ueda Medical Center
Shinsuma Hospital
Shirahama Hamayu Hospital
Shirakawa Kosei General Hospital
Shiroishi neurosurgical Hospital
Shiroyama Hospital
Shiseikai Daini Hospital
Shizuoka Children's Hospital
Shizuoka City Hospital
Shizuoka General Hospital
Shobara Red Cross Hospital
Shonai Hospital
Shonan Kamakura General Hospital
Showa General Hospital
Showa Inan General Hospital
Showa University Fujigaoka Hospital
Showa University Hospital
Social Insurance Chukyo Hospital
Social Insurance Chuo General Hospital
Social Insurance Takahama Hospital
Soseikai General Hospital
South Miyagi Medical Center
Southern Tohoku General Hospital
St Marianna University School of Medicine Toyoko Hospital
St Francisco Hospital
St Marianna University School of Medicine Hospital
Steeel Memorial Hirohata Hospital
Steel Memorial Yawata Hospital
Suiseikai Kajikawa Hospital
Suita Municipal Hospital
Suwa Central Hospital
Suwakohan Hospital
Suzuka Kaisei Hospital
Tachikawa Medical Center
Takada Chuo Hospital
Takamatsu Municipal Hospital
Takamatsu Red Cross Hospital
Takarazuka City Hospital
Takarazuka Daiichi Hospital
Takashima Municipal Hospital
Takatsuki General Hospital
Takeda General Hospital
Takikawa Neurosurgery Hospital

(Continued)

Appendix Table 1. *(Continued)*

Tama-Hokubu Medical Center
Tama-Nanbu Chiiki Hospital
Tamana Central Hospital
Tane General Hospital
Tano Hospital
Tanushimaru Central Hospital
Tatebayashi Kosei Hospital
Teiko University Chiba Medical Center
Teikyo University School of Medicine Hospital, Mizonokuchi
Tekeda Hospital
Tenshindo Hetsugi Hospital
The Taiju-Kai Foundation Social Medical Corporation Kaisei General Hospital
Tochigi National Hospital
Toho University Ohashi Medical Center
Tohoku KoseiNenkin Hospital
Tokai Central Hospital of the Mutual Aid Association of Public School Teachers
Tokai University Hachioji Hospital
Tokai University Hospital
Tokai University Oiso Hospital
Toki General Hospital
Tokuda Neurosurgical Hospital
Tokushima Prefectural Central Hospital
Tokushima Prefectural Kaifu Hospital
Tokushima University Hospital
Tokuyama Central Hospital
Tokyo Kyosai Hospital
Tokyo Medical And Dental University Hospital Faculity of Medicine
Tokyo Medical University Hospital
Tokyo Medical University Ibaraki Medical Center
Tokyo Metropalitan Hiroo Hospital
Tokyo Metropolitan Health and Medical Corporation Toshima Hospital
Tokyo Metropolitan Ohtsuka Hospital
Tokyo Metropolitan Police Hospital
Tokyo Women's Medical University Hospital
Tokyo Women's Medical University Yachiyo Medical Center
Tokyo Women's University Medical Center East
Tokyo-Teishin Hospital
Tokyo-West Tokushukai Hospital
Tokyu Medical University Hachioji Medical Center
Tomakomai Neurosurgical Hospital
Tomakomai Nissho Hospital
Tomei Atsugi Hospital
Tominaga Hospital
Tomioka General Hospital
Tonami General Hospital
Tone Central Hospital
Tosei General Hospital
Tottori Pref.Kousei Hospital
Tottori Red Cross Hospital
Tottori Seikyo Hospital
Tottori University Hospital
Toyama City Hospital

(Continued)

Appendix Table 1. *(Continued)*

Toyama Prefectural Central Hospital
Toyama Rosai Hospital
Toyohashi Medical Center
Toyokawa City Hospital
Toyooka Chuo Hospital
Toyooka Public Hospitals' association Toyooka Hospital
Toyota Kosei Hospital
Tsuchiura Kyodo General Hospital
Tsukazaki Hospital
Tsukuba Medical Center Hospital
Tsushima City Hospital
Tsuyama Central Hospital
Ube Industries, ltd. Central Hospital
Ueyama Hospital.
Ugadake Hospital
University Hospital of the Ryukyus
University of Miyazaki Hospital
University of Tokyo Hospital
University of Tsukuba Hospital
University of Yamanashi Hospital
Urasoe General Hospital
Ushiku Aiwa General Hospital
Ushioda General Hospital
Uwajima City Hospital
Uwajima Tokushukai Hospital
Veritas Hospital
Wada Hospital
Wakakusa Dai-ichi Hospital
Wakayama Co-operative Hospital
Wakayama Medical University Hospital
Wakayama Medical University Kihoku Hospital
Wakayama Rosai Hospital
Wakayama Saiseikai Hospital
Yaentoge Neurosurgery Hospital
Yagi Neurosurgical Hospital
Yaizu City General Hospital
Yamachika Memorial Hospital
Yamada Kinen Hospital
Yamada Red Cross Hospital
Yamagata City Hospital Saiseikan
Yamagata Prefectural Kahoku Hospital
Yamagata Prefectural Shinjo Hospital
Yamagata University Hospital
Yamaguchi Grand Medical Center
Yamaguchi Red Cross Hospital
Yamaguchi Rousai Hospital
Yamaguchi University Hospital
Yamamoto Memorial Hospital
Yamanashi Kosei Hospital
Yamanashi Prefectural Central Hospital
Yamanashi Red Cross Hospital
Yamashiro Public Hospital
Yamato Municipal Hospital
Yao Tokushukai General Hospital
Yasugi municipal Hospital
Yatsuo General Hospital
Yatsushiro Health Insurance General Hospital
Yahata General Hospital

(Continued)

Appendix Table 1. *(Continued)*

Yayoigaoka Hospital
Yodogawa Christian Hospital
Yokkaichi Municipal Hospital
Yokohama Central Hospital
Yokohama City Minato Red Cross Hospital
Yokohama City University Hospital
Yokohama City University Medical Center
Yokohama General Hospital
Yokohama Rosai Hospital
Yokohama Sakae Kyosai Hospital
Yokohama Shin-midori General Hospital
Yokohama Stroke and Brain Center
Yokohamashintoshi Neurosurgical Hospital
Yokosuka General Hospital Uwamachi
Yomeikai Obase Hospital
Yonabaru Chu-ou Hospital
Yonago Medical Center
Yonezawa City Hospital
Yuaikai Hospital
Yukioka Hospital

Appendix Table 2. *Number (%) of responding hospitals* (n = 724) *with the recommended elements of acute stroke care capacity in Japan, based on geographical classification*

Category	Components	*n*	%	MEA-central (*n* = 382)	MEA-outlying (*n* = 240)	McEA-central (*n* = 90)	McEA-outlying (*n* = 12)	*P* value*
Personnel	Board-certified neurologist	351	48.5	210 (55)	109 (45.4)†	28 (31.1)†	4 (33.3)	<.001
	Board-certified neurosurgeon	673	93.0	359 (94)	220 (91.7)	85 (94.4)	9 (75)	.084
	Interventional/endovascular physicians	269	37.2	174 (45.5)	78 (32.5)†	16 (17.8)†	1 (8.3)†	<.001
	Critical care medicine	157	21.7	90 (23.6)	53 (22.1)	14 (15.6)	0 (0)	.098
	Physical medicine and rehabilitation	110	15.2	64 (16.8)	37 (15.4)	8 (8.9)	1 (8.3)	.279
	Rehabilitation therapy	716	98.9	379 (99.2)	236 (98.3)	90 (100)	11 (91.7)	.099
	Stroke rehabilitation nurses	99	13.7	64 (16.8)	28 (11.7)	7 (7.8)†	0 (0)	.045
Diagnostic (24/7)	CT	716	98.9	379 (99.2)	236 (98.3)	90 (100)	11 (91.7)	.099
	MRI with diffusion	621	85.8	334 (87.4)	198 (82.5)	77 (85.6)	11 (91.7)	.365
	Digital cerebral angiography	585	80.8	316 (82.7)	184 (76.7)	77 (85.6)	8 (66.7)	.084
	CTA	606	83.7	323 (84.6)	197 (82.1)	77 (85.6)	9 (75)	.616
	Carotid duplex U/S	248	34.3	142 (37.2)	73 (30.4)	29 (32.2)	4 (33.3)	.365
	TCD	121	16.7	80 (20.9)	34 (14.2)†	7 (7.8)†	0 (0)	.003
Surgical	CEA	587 (673)	87.2	329 (91.1)	184 (84.8)†	66 (78.6)†	8 (72.7)	.002
	Clipping of IA	657 (699)	94.0	350 (95.1)	215 (92.7)	83 (94.3)	9 (81.8)	.182
	Hematoma removal/draining	660 (701)	94.2	353 (95.4)	216 (93.1)	82 (93.2)	9 (81.8)	.151
	Coiling of IA	348 (624)	55.8	215 (64)	107 (52.7)†	23 (31.1)†	3 (27.2)†	<.001
	IA reperfusion therapy	486 (639)	76.1	272 (79.8)	156 (73.9)	52 (68.4)	6 (54.6)	.035
Infrastructure	Stroke unit	126 (712)	17.7	83 (22.1)	37 (15.7)	6 (6.7)†	0 (0)	.001
	ICU	346 (724)	47.8	186 (48.7)	115 (47.9)	39 (43.3)	6 (50)	.835
	Operating room staffed 24/7	443	61.2	256 (67.0)	142 (59.2)	42 (46.7)†	3 (25.0)†	<.001
	Interventional services coverage 24/7	275	38.0	182 (47.6)	77 (32.1)†	15 (16.7)†	1 (8.3)†	<.001
	Stroke registry	228	31.5	134 (35.1)	69 (28.8)	23 (25.6)	2 (16.7)	.133
Education	Community education	358	49.4	196 (51.3)	127 (52.9)	31 (34.4)†	4 (33.3)	.011
	Professional education	424	58.6	238 (62.3)	143 (59.6)	39 (43.3)†	4 (33.3)	.003
PSC Elements	t-PA–certified physician	662 (706)	93.8	360 (95.7)	214 (93)	79 (88.8)†	9 (81.8)	.021
	Acute stroke team	183 (702)	26.1	120 (32.4)	50 (21.7)†	10 (11.1)†	3 (25)	<.001
	NIHSS	514 (721)	71.3	296 (77.5)	165 (69.3)†	47 (52.2)†	6 (50)	<.001
	Written t-PA protocol	616 (721)	85.4	338 (88.7)	201 (84.1)	69 (76.7)†	8 (72.7)	.012
	Hotline with emergency medical services	418 (718)	58.2	218 (57.2)	138 (58.7)	53 (58.9)	9 (75)	.700

Abbreviations: CEA, carotid endarterectomy; CT, computed tomography; CSC, comprehensive stroke center; CTA, computed tomography angiography; IA, intracranial aneurysm; ICH, intracerebral hemorrhage; ICU, intensive care unit; McEA, micropolitan employment areas; MRI, magnetic resonance imaging; NIHSS, National Institutes of Health Stroke Scale; TCD, transcranial Doppler; t-PA, tissue plasminogen activator; U/S, ultrasonography.

*Fisher's exact test.

†$P < .05$ versus MEA-central, Fisher's exact test.

Appendix Table 3. *Categorical and total CSC scores of the responding hospitals based on geographical classifications*

	Category	MEA-central (n = 382)	MEA-outlying (n = 240)	McEA-central (n = 90)	McEA-outlying (n = 12)	P value*
CSC scores (median, IQR)	Personnel	3 (3-4)	3 (2-4)†	2 (2-3)†	2 (2-3)†	<.001
	Diagnostic	4 (4-5)	4 (3-5)†	4 (4-5)	4 (3-4.5)	.077
	Surgical/interventional	5 (3-5)	4 (3-5)†	4 (3-4)†	3.5 (1.0-4.5)†	<.001
	Infrastructure	2 (1-3)	2 (1-3)†	1 (0-2)†	1 (0-2)†	<.001
	Education	1 (0-2)	1 (0-2)	1 (0-1)†	0 (0-1.5)	<.001
	Total	16 (12-18)	14 (11-17)†	13 (10-15)†	12.5 (6.5-14)†	<.001

Abbreviations: CSC, comprehensive stroke center; IQR, interquartile range; MEA, metropolitan employment areas; McEA, micropolitan employment areas.

*Kruskal-Wallis test.

†Wilcoxon test, $P < .05$ versus MEA-central.

Appendix Table 4. *The impact of availability of t-PA protocol on the volume of stroke interventions on multivariate linear regressions adjusted for other hospital characteristics*

	t-PA protocol (+)			
	β	P value	95% CI	
t-PA	6.40	<.001	4.73	8.08
ICH	6.79	<.001	4.55	9.03
Clipping	14.22	<.001	8.32	20.12
Coiling	5.73	<.001	2.84	8.63

Abbreviations: CI, confidence interval; ICH, intracerebral hemorrhage; t-PA, tissue plasminogen activator.

The hospitals without a t-PA protocol (t-PA (-) were considered as a reference.

Appendix Table 5. *The impact of the total CSC score on the volume of stroke interventions on multivariate linear regressions adjusted for other hospital characteristics*

	Total CSC score												
	Q2				Q3				Q4				
	β	*P* value	95% CI		β	*P* value	95% CI		β	*P* value	95% CI		*P* for trend
t-PA	3.13	<.001	1.63	4.63	6.85	<.001	5.42	8.29	12.21	<.001	10.49	13.94	<.001
ICH	4.45	<.001	2.36	6.53	8.63	<.001	6.63	10.63	13.30	<.001	10.89	15.72	<.001
Clipping	8.08	.004	2.60	13.56	16.15	<.001	10.91	21.38	34.82	<.001	28.47	41.18	<.001
Coiling	1.44	.304	−1.30	4.18	8.09	<.001	5.48	10.71	15.74	<.001	12.57	18.91	<.001

Abbreviations: CI, confidence interval; DPC, diagnosis procedure combination; ICH, intracerebral hemorrhage; t-PA, tissue plasminogen activator.

Total CSC scores were categorized into quartiles (Q1: 0-10, Q2: 11-13, Q3: 14-17, and Q4: 18-24) and treated as dummy variables. The hospitals with the total CSC score classified into Q1 were considered as a reference. Other adjustment covariates were the number of beds, academic status, geographical locations, and participation on the DPC-based payment system.

Appendix Table 6. *The volume of stroke interventions in 2009 in the responding hospitals*

	n	%	Median	IQR	Range
t-PA infusion	727	97.1	5	2-10	0-60
Clipping of IA	724	96.7	15	15-27	0-356
ICH removal	720	96.1	5.5	2-12	0-85
CEA	678	90.5	0	0-2	0-41
Coiling of IA	698	93.2	3	0-11	0-116
i.a. reperfusion	678	90.5	0	0-2	0-41
CAS	697	93.1	1	0-7	0-164

Abbreviations: CAS, carotid stenting; CEA, carotid endarterectomy; i.a., intra-arterial; IA, intracranial aneurysm; IQR, interquartile range; t-PA, tissue plasminogen activator.

n, number of hospitals replying to the question of case volume of stroke interventions performed in 2009; %, percentage of hospitals replying to the question of case volume of stroke interventions performed in 2009 in the responding hospitals.

Effects of Comprehensive Stroke Care Capabilities on In-Hospital Mortality of Patients with Ischemic and Hemorrhagic Stroke: J-ASPECT Study

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Abstract

Background: The effectiveness of comprehensive stroke center (CSC) capabilities on stroke mortality remains uncertain. We performed a nationwide study to examine whether CSC capabilities influenced in-hospital mortality of patients with ischemic and hemorrhagic stroke.

Methods and Results: Of the 1,369 certified training institutions in Japan, 749 hospitals responded to a questionnaire survey regarding CSC capabilities that queried the availability of personnel, diagnostic techniques, specific expertise, infrastructure, and educational components recommended for CSCs. Among the institutions that responded, data on patients hospitalized for stroke between April 1, 2010 and March 31, 2011 were obtained from the Japanese Diagnosis Procedure Combination database. In-hospital mortality was analyzed using hierarchical logistic regression analysis adjusted for age, sex, level of consciousness on admission, comorbidities, and the number of fulfilled CSC items in each component and in total. Data from 265 institutions and 53,170 emergency-hospitalized patients were analyzed. Mortality rates were 7.8% for patients with ischemic stroke, 16.8% for patients with intracerebral hemorrhage (ICH), and 28.1% for patients with subarachnoid hemorrhage (SAH). Mortality adjusted for age, sex, and level of consciousness was significantly correlated with personnel, infrastructural, educational, and total CSC scores in patients with ischemic stroke. Mortality was significantly correlated with diagnostic, educational, and total CSC scores in patients with ICH and with specific expertise, infrastructural, educational, and total CSC scores in patients with SAH.

Conclusions: CSC capabilities were associated with reduced in-hospital mortality rates, and relevant aspects of care were found to be dependent on stroke type.

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Introduction

In Japan, stroke is the third-leading cause of death, as well as a leading cause of long-term disability. Almost 270,000 individuals in Japan have a new or recurrent stroke each year, and nearly 120,000 individuals die following a stroke [1]. In 2000, the Brain Attack Coalition discussed the concept of stroke centers and proposed two types of centers: comprehensive [2] and primary [3]. Most patients with stroke can be appropriately treated at a primary stroke center (PSC), and the Joint Commission has established programs for certifying PSCs and measuring their performance [4]. The concept and recommended key components of comprehensive stroke centers (CSCs) enable intensive care and specialized techniques that are not available at most PSCs [2,5].

Table 1. Number and percentage of participating hospitals (n = 265) with the recommended items of comprehensive stroke care capabilities.

Components	Items	*n*	%
Personnel	Neurologists	143	54.0
	Neurosurgeons	251	94.7
	Endovascular physicians	118	44.5
	Critical care medicine	65	24.5
	Physical medicine and rehabilitation	42	15.8
	Rehabilitation therapy	265	100
	Stroke rehabilitation nurses	38	14.6
Diagnostic techniques	CT	264	99.6
	MRI with diffusion	237	89.4
	Digital cerebral angiography	226	85.6
	CT angiography	234	88.3
	Carotid duplex ultrasound	102	38.5
	TCD	53	20.2
Specific expertise	Carotid endarterectomy	231	87.2
	Clipping of intracranial aneurysm	250	94.3
	Hematoma removal/draining	253	95.5
	Coiling of intracranial aneurysm	153	57.7
	Intra-arterial reperfusion therapy	199	75.1
Infrastructure	Stroke unit	55	20.8
	Intensive care unit	169	63.8
	Operating room staffed 24/7	185	70.0
	Interventional services coverage 24/7	122	46.0
	Stroke registry	109	41.8
Education	Community education	147	55.7
	Professional education	171	64.8

CT, computed tomography; MRI, magnetic resonance imaging; TCD, transcranial Doppler.
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Although stroke performance measures have been developed to monitor and improve quality of care, a substantial proportion of patients do not receive effective treatments, and population-based studies have been called for to evaluate the successful translation of evidence-based medicine into clinical practice [4] Organized stroke unit care is a form of in-hospital care provided by nurses, doctors, and therapists who work as a coordinated team specialized in caring for patients with stroke [6]. The effectiveness of organized stroke care has been reported for different ischemic stroke subtypes in the organized care index (OCI) using data from the Registry of the Canadian Stroke Network [7,8]. However, the effectiveness of CSC capabilities on the mortality of patients with ischemic and hemorrhagic stroke remains uncertain. In this study, we examined whether CSC capabilities influence in-hospital mortality for all types of stroke in a real-world setting by using data from the J-ASPECT nationwide stroke registry (obtained from the Japanese Diagnosis Procedure Combination [DPC]-based Payment System) [9].

Methods

Of the 1,369 certified training institutions of the Japan Neurosurgical Society, the Japanese Society of Neurology, and/or the Japan Stroke Society, 749 hospitals responded to a questionnaire survey regarding CSC capabilities. The CSC capabilities were assessed using 25 items specifically recommended for CSCs [2] that were divided into 5 components regarding (1) personnel (seven items: board-certified neurologists, board-certified neurosurgeons, board-certified endovascular physicians, board-certified physicians in critical care medicine, board-certified physicians in physical medicine and rehabilitation, personnel in rehabilitation therapy, and stroke rehabilitation nurses), (2) diagnostic techniques (six items: 24 hours/day, 7 days/week [24/7] availability of computed tomography [CT], magnetic resonance imaging [MRI] with diffusion-weighted imaging, digital cerebral angiography, CT angiography, carotid duplex ultrasound, and transcranial Doppler), (3) specific expertise (five items: carotid endarterectomy, clipping of intracranial aneurysms [IAs], removal of intracerebral hemorrhage [ICH], coiling of IAs, and intra-arterial reperfusion therapy), (4) infrastructure (five items: stroke unit, intensive care unit, operating room staffed 24/7, interventional services coverage 24/7, and stroke registry), and (5) educational components (two items: community education and professional education). A score of 1 point was assigned if the hospital met each recommended item, yielding a total CSC score of up to 25. The scores were also summed for each component (subcategory CSC score). The impact of specific aspects of acute stroke care (monitoring, early rehabilitation, admission to stroke care unit [SCU], acute stroke team, the organized stroke care index [7], existence of a tissue plasminogen activator [t-PA]

Table 2. Demographics of the study cohort according to the Diagnosis Procedure Combination (DPC) discharge database study in a comparison of hospitals that agreed to participate in the present study and those that did not.

	Participating hp	Non-participating hp	P value#
	(n = 265)	(n = 484)	
Hospital characteristics (CSC scores)			
Total score (25 items)	15.4±4.2	13.5±4.6	<0.001
Personnel (7 items)	3.5±1.2	3.1±1.3	<0.001
Diagnostic techniques (6 items)	4.2±1.2	3.9±1.3	0.002
Specific expertise (5 items)	4.0±1.4	3.6±1.6	<0.001
Infrastructure (5 items)	2.4±1.4	1.9±1.4	<0.001
Education (2 items)	1.2±0.8	1.0±0.8	0.002
Number of beds, n (%)			
20–49	3 (1.1)	13 (2.7)	<0.001
50–99	9 (3.4)	21 (4.3)	
100–299	66 (24.9)	166 (34.3)	
300–499	97 (36.6)	163 (33.7)	
500–	90 (34.0)	117 (24.2)	
Annual stroke cases, n (%)			
0–49	8 (3.0)	43 (8.9)	0.003
50–99	31 (11.7)	47 (9.7)	
100–199	56 (21.1)	143 (29.5)	
200–299	67 (25.3)	88 (18.2)	
300–	92 (34.7)	136 (28.1)	
Annual volume of t-PA infusion	8.3	6.4	0.002

#Wilcoxon rank-sum test.
CSC, comprehensive stroke center.
Hp, hospital.
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protocol, number of t-PA cases/year, and number of acute stroke cases/year) on stroke mortality was also examined. This survey was completed by neurosurgeons or neurologists in the responding hospitals and returned by mail. Any incomplete answers were completed in follow-up phone interviews with the neurosurgeons or neurologists of the study group. The English version of the survey is shown in File S1.

This cross-sectional survey used the DPC discharge database from participating institutions in the J-ASPECT Study. The DPC is a mixed case patient classification system that was launched in 2002 by the Ministry of Health, Labor, and Welfare of Japan and was linked with a lump-sum payment system [9]. Of the 749 hospitals that responded to the institutional survey regarding CSC capabilities, 265 agreed to participate in the DPC discharge database study (File S2). Computer software was developed to identify patients hospitalized because of acute stroke from the annual de-identified discharge database by using the International Classification of Diseases (ICD)-10 diagnosis codes related to ischemic stroke (I63.0-9), nontraumatic ICH (ICH: I61.0-9, I62.0-1, and I62.9), and subarachnoid hemorrhage (SAH: I60.0-9). Because of major differences in their typical prognosis, patients with transient ischemic attack were excluded. Patients hospitalized because of ischemic and hemorrhagic stroke between April 1, 2010 and March 31, 2011 were included; however, patients with scheduled admissions were excluded from analysis. The following data were collected from the database: unique identifiers of hospitals, patients' age and sex, diagnoses, comorbidities at admission, in-hospital use of medications (antihypertensive agents, oral hypoglycemic agents, insulin, antihyperlipidemic agents, statins, anticoagulant agents, or antiplatelet agents), smoking, arrival by ambulance or not, level of consciousness at admission according to the Japan Coma Scale [10], and discharge status. The Japan Coma Scale [11] was originally published in 1974, the same year as the Glasgow Coma Scale (GCS) [12], and it remains one of the most popular grading scales for assessing impaired consciousness among health care professionals and personnel for emergency medical services in Japan. Grading with the 1-, 2-, and 3-digit codes corresponds to the following statuses: 1) the patient is awake in the absence of any stimulation, 2) the patient can be aroused but reverts to the previous state after the cessation of stimulation, and 3) the patient cannot be aroused even by forceful mechanical stimulation. Each specific digit status is further subdivided into three levels: 1-digit code into 1, 2, and 3; 2-digit code into 10, 20, and 30; and 3-digit code into 100, 200, and 300 (Table S1). In addition to these nine grades, a normal level of consciousness is graded as zero. Consciousness level on admission was determined by the physician and data on all medication use was collected electronically from the claim data. Comorbidity was determined primarily from the ICD-10 code, but was also checked against what medications and procedures the patient was receiving/undergoing, to see if these were compatible with the code data. Smoking was defined by the physician's record, which rated patients as active or inactive smokers. In-hospital mortality, defined as death by the time of discharge from the hospital, was analyzed with the total and subcategory CSC scores using hierarchical logistic regression analysis adjusted for age, sex,

Table 3. Demographics of the patient study cohort at the time of diagnosis and hospital characteristics according to stroke type.

	Total	Ischemic Stroke	Intracerebral hemorrhage	Subarachnoid hemorrhage
	(n = 53,170)	(n = 32,671)	(n = 15,699)	(n = 4,934)
Male, n (%)	29,353 (55.2)	18,816 (57.6)	9,030 (57.5)	1,584 (32.1)
Age, mean years ±SD	72.5±13.1	74.4±12.2	70.7±13.5	64.7±14.8
Hypertension, n (%)	39,918 (75.1)	22,531 (69.0)	13,281 (84.6)	4,229 (85.7)
Diabetes Mellitus, n (%)	13,725 (25.8)	9,318 (28.5)	3,278 (20.9)	1,174 (23.8)
Hyperlipidemia, n (%)	15,015 (28.2)	11,104 (34.0)	2,529 (16.1)	1,412 (28.6)
Smoking (n = 4,4842)	12,761 (24.0)	8,188 (25.1)	3,540 (22.5)	1,074 (21.8)
Medications during hospitalization				
Antihypertensive agent	34,136 (64.2)	17,694 (54.2)	12,537 (79.9)	4,019 (81.5)
Anti-renin-angiotensin system agent	19,881 (37.4)	10,262 (31.4)	8,280 (52.7)	1,410 (28.6)
Ca channel antagonist	25,984 (48.9)	10,469 (32.0)	11,719 (74.6)	3,903 (79.1)
Sympathetic antagonist	6,334 (11.9)	3,821 (11.7)	2,172 (13.8)	364 (7.4)
*β-blocker, α,β-blocker	4,357 (8.2)	3,048 (9.3)	1,133 (7.2)	188 (3.8)
α-blocker	2,374 (4.5)	953 (2.9)	1,232 (7.8)	200 (4.1)
Diuretic agent	9,950 (18.7)	5,860 (17.9)	3,074 (19.6)	1,049 (21.3)
Loop diuretic	7,434 (14.0)	4,609 (14.1)	1,912 (12.2)	940 (19.1)
Other diuretic	4,425 (8.3)	2,527 (7.7)	1,653 (10.5)	255 (5.2)
Antidiabetic agent	10,295 (19.4)	6,784 (20.8)	2,473 (15.8)	1,075 (21.8)
Insulin	7,654 (14.4)	4,597 (14.1)	2,044 (13.0)	1,046 (21.2)
Oral antidiabetic agent	5,749 (10.8)	4,459 (13.6)	1,110 (7.1)	197 (4.0)
Antihyperlipidemic agent	12,387 (23.3)	9,264 (28.4)	1,839 (11.7)	1,310 (26.6)
Statin	10,099 (19.0)	7,840 (24.0)	1,366 (8.7)	912 (18.5)
Antiplatelet agent	23,635 (44.5)	21,746 (66.6)	625 (4.0)	1,298 (26.3)
Aspirin	11,929 (22.4)	11,119 (34.0)	378 (2.4)	447 (9.1)
Japan Coma Scale				
0, n (%)	19,635 (36.9)	15,027 (46.0)	3,620 (23.1)	1,024 (20.8)
1-digit code, n (%)	19,371 (36.4)	12,375 (37.9)	5,934 (37.8)	1,117 (22.6)
2-digit code, n (%)	6,937 (13.0)	3,396 (10.4)	2,705 (17.2)	852 (17.3)
3-digit code, n (%)	7,227 (13.6)	1,873 (5.7)	3,440 (21.9)	1,941 (39.3)
Emergency admission by ambulance, n (%)	31,995 (60.2)	17,336 (53.1)	10,909 (69.5)	3,830 (77.6)
Average days in hospital (range)	21 (11–40)	20 (12–38)	22 (10–43)	30 (12–54)
Hospital characteristics (CSC scores)				
Total score (25 items)		16.7±3.8	16.8±3.4	17.1±3.4
Personnel (7 items)		3.7±1.2	3.7±1.2	3.8±1.2
Diagnostic techniques (6 items)		4.4±1.1	4.5±1.0	4.5±1.0
Specific expertise (5 items)		4.4±1.0	4.4±0.9	4.5±0.8
Infrastructure (5 items)		2.8±1.3	2.9±1.3	2.9±1.3
Education (2 items)		1.4±0.8	1.4±0.8	1.4±0.8

CSC, comprehensive stroke center.
*A composite variable with a pure beta antagonist and a mixed alpha/beta adrenergic antagonist (e.g., labetalol).
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Japan Coma Scale score, comorbidities, and institutional difference.

Ethics Statement

This research plan was designed by the authors and approved by the Institutional Review Board of the National Cerebral and Cardiovascular Center, which waived the requirement for individual informed consent.

Statistical Analysis

We used hierarchical logistic regression models [13,14] to estimate odds ratios (ORs) for in-hospital mortality. Each model had two levels of hierarchy (hospital and patient) while considering the random effects of hospital variation, as well as fixed effects of CSC score and patient effects of age, sex, and level of consciousness. The total score and each subcategory score were analyzed separately. We also divided CSC score into quintiles and analyzed the trend with the Cochran-Armitage trend test. The

Table 4. The impact of total comprehensive stroke care (CSC) score on in-hospital mortality after ischemic stroke, adjusted by age, sex, and level of consciousness at admission according to the Japan Coma Scale (JCS).

Factor	OR	95% CI	P value
Male	1.23	1.12–1.35	<0.001
Age	1.40	1.34–1.47	<0.001
CSC total score	0.97	0.96–0.99	0.001
JCS			
normal	1		
one-digit code	2.40	2.11–2.74	<0.001
two-digit code	7.46	6.47–8.60	<0.001
three-digit code	21.62	18.69–25.02	<0.001

CI, confidence interval; CSC, comprehensive stroke care; JCS, Japan Coma Scale; OR, odds ratio.
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difference between participating and non-participating hospitals in the DPC discharge study was determined by Wilcoxon rank-sum test. The analyses were performed using SAS version 9.2 (SAS Institute Inc., Cary, NC, USA) and STATA version 12 (STATA Corp, College Station, TX, USA).

Results

A total of 265 hospitals participated in this study. The number and percentage of the participating hospitals with the recommended items of CSC capabilities are shown in Table 1. The distribution of total CSC scores ranged from 1 to 23 (mean: 15.4, median: 14 standard deviation [SD]: 4.2, interquartile range [IQR]: 11–18). Because we initially sent the CSC questionnaire to 749 hospitals, we sought to determine whether there was a selection bias in stroke care capabilities that could have impacted which hospitals returned the questionnaire. We found that such a bias did exist; in fact, the total CSC scores, subcategory CSC scores and annual volume of t-PA infusion, with the exception of the diagnostic techniques and education/research subcategories, were significantly higher for the participating hospitals than for the non-participating hospitals (Table 2).

Data from 265 institutions and 53,170 emergency-hospitalized patients (age in years, mean ±SD: 72.5±13.1; male: 55.2%) were analyzed. Patient demographics according to stroke type at the time of diagnosis are shown in Table 3. The study cohort included 32,671 patients with ischemic stroke (age: 74.4±12.2 years; male: 57.6%), 15,699 with ICH (age: 70.7±13.5 years; male: 57.5%), and 4,934 with SAH (age: 64.7±14.8 years; male: 32.1%). Use of antihypertensive agents, antidiabetic agents, antihyperlipidemic agents, and antiplatelet agents is also shown in Table 3. Almost 60% of the patients arrived by ambulance, with the incidence ranging from 77.6% for SAH to 53.1% for ischemic stroke. These rates of arrival by ambulance based on stroke type were in accordance with different degrees of stroke severity, as reflected by level of consciousness. Hospital characteristics shown by total and subcategory CSC scores did not reveal any significant differences with respect to stroke type.

Overall, mortality rates were 7.8% for ischemic stroke, 16.8% for ICH, and 28.1% for SAH. Table 4–6 show the results of a hierarchical logistic regression analysis of these data. Mortality of patients with ischemic stroke was significantly correlated with male sex (OR = 1.23), age (10 incremental years, OR = 1.4), and level of consciousness (1-digit code: OR = 2.4, 2-digit code: OR = 7.46, 3-digit code: OR = 21.62, versus zero [normal consciousness {control}]) as patient characteristics, and total CSC score (OR = 0.97) adjusted for age, sex, and level of consciousness as a hospital characteristic (Table 4). Mortality of patients with ICH was also significantly correlated with male sex (OR = 1.72), age (10 incremental years, OR = 1.36), and level of consciousness (1-digit code: OR = 1.45, 2-digit code: OR = 4.22, 3-digit code: OR = 49.59, versus zero as control) as patient characteristics and total CSC score (OR = 0.97) adjusted for age, sex, and level of consciousness as a hospital characteristic (Table 5). Mortality of

Table 5. The impact of total comprehensive stroke care (CSC) score on in-hospital mortality after intracerebral hemorrhage, adjusted by age, sex, and level of consciousness at admission according to the Japan Coma Scale (JCS).

Factor	OR	95% CI	P value
Male	1.72	1.54–1.92	<0.001
Age	1.36	1.30–1.42	<0.001
CSC total score	0.97	0.95–0.99	0.003
JCS			
normal	1		
one-digit code	1.45	1.14–1.83	0.002
two-digit code	4.22	3.34–5.33	<0.001
three-digit code	49.59	40.12–61.27	<0.001

CI, confidence interval; CSC, comprehensive stroke care; JCS, Japan Coma Scale; OR, odds ratio.
doi:10.1371/journal.pone.0096819.t005

Table 6. The impact of total comprehensive stroke care (CSC) score on in-hospital mortality after subarachnoid hemorrhage, adjusted by age, sex, and level of consciousness at admission according to the Japan Coma Scale (JCS).

Factor	OR	95%CI	P value
Male	1.39	1.17–1.65	<0.001
Age	1.37	1.29–1.45	<0.001
CSC total score	0.95	0.93–0.98	<0.001
JCS			
normal	1		
one-digit code	1.05	0.75–1.46	0.785
two-digit code	2.01	1.46–2.77	<0.001
three-digit code	17.13	13.14–22.35	<0.001

CI, confidence interval; CSC, comprehensive stroke care; JCS, Japan Coma Scale; OR, odds ratio.
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patients with SAH was likewise significantly correlated with male sex (OR = 1.39), age (10 incremental years, OR = 1.37), and level of consciousness (2-digit code: OR = 2.01, 3-digit code: OR = 17.12, versus zero as control) as patient characteristics and total CSC score (OR = 0.95) adjusted for age, sex, and level of consciousness as a hospital characteristic. Therefore, total CSC score was independently associated with in-hospital mortality for all stroke types after adjusting for age, sex, and stroke severity (Table 6). The impact of total CSC score on in-hospital mortality for ischemic stroke and ICH remained significant after adjustment for age, sex, severity of stroke, and existence of comorbid conditions (hypertension, diabetes mellitus, and hyperlipidemia) (Table S2–S4).

Table 7–9 show the correlations between CSC subcategory scores and in-hospital mortality adjusted for age, sex, and level of consciousness depending on the different stroke types: mortality of patients with ischemic stroke was significantly correlated with subcategory scores in personnel (OR = 0.93), infrastructure (OR = 0.94), and education (OR = 0.89) (Table 7). Mortality of patients with ICH was significantly correlated with subcategory scores in diagnostic technique (OR = 0.91), infrastructure (OR = 0.92), and education (OR = 0.91) (Table 8). Mortality of patients with SAH was significantly associated with subcategory scores in personnel (OR = 0.91) specific expertise (OR = 0.83), infrastructure (OR = 0.89), and education (OR = 0.84) (Table 9). We found that while infrastructure and education subcategory CSC scores significantly impacted outcomes for all types of stroke, other subcategory CSC scores were differentially associated with in-hospital mortality depending on stroke type.

Figure 1 shows the impact of total CSC score classified into quintiles (Q1: 4–12, Q2: 13–14, Q3: 15–17, Q4: 18, Q5: 19–23) on the in-hospital mortality of patients with all types of stroke (a), ischemic stroke (b), ICH (c), and SAH (d) after adjusting for age, sex and level of consciousness. There was a significant association between total CSC score and in-hospital mortality in all types of stroke (all P<0.001) (Table 4–6). Figure 2 illustrates the impact of total CSC score on the in-hospital mortality of patients with all types of stroke (a), ischemic stroke (b), ICH (c), and SAH (d) after adjustment for age; sex; level of consciousness; and incidence of hypertension, hyperlipidemia, and diabetes mellitus. The association between total CSC score and in-hospital mortality in patients after all types of stroke (a), ischemic stroke (b), and ICH (c) remained significant after adjustment for age; sex; level of consciousness; and incidence of hypertension, hyperlipidemia, and diabetes mellitus. This same association was not evident in patients with SAH (P = 0.601) (Table 10).

Hospitals with higher CSC scores were also more likely to provide early rehabilitation, improved monitoring, the possibility of admission to an SCU, presence of an acute stroke care team, existence of a t-PA protocol, greater numbers of t-PA cases/year, and higher scores on the organized stroke care index. In addition to the CSC score, the processes of acute stroke care, such as admission to SCU, presence of an acute stroke team, the organized stroke care index [7], and number of acute stroke cases/staff physician significantly impacted in-hospital mortality after all types of acute stroke, although in some cases, to a greater or lesser degree for the different types of stroke (Table 11–14).

Discussion

Using the nationwide discharge data obtained from the Japanese DPC-based Payment System, we evaluated the effect of

Table 7. The impact of subcategory CSC score on in-hospital mortality after ischemic stroke adjusted by age, sex and JCS.

Component	OR	95% CI	P value
Personnel	0.93	0.88–0.98	0.008
Diagnostic techniques	0.95	0.90–1.01	0.090
Specific expertise	0.96	0.90–1.01	0.136
Infrastructure	0.94	0.90–0.99	0.014
Education/research	0.89	0.83–0.96	0.003

CI, confidence interval; CSC, comprehensive stroke care; JCS, Japan Coma Scale; OR, odds ratio.
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Table 8. The impact of subcategory CSC score on in-hospital mortality after intracerebral hemorrhage adjusted by age, sex and JCS.

Component	OR	95% CI	P value
Personnel	0.98	0.92–1.04	0.523
Diagnostic techniques	0.91	0.85–0.98	0.012
Specific expertise	0.93	0.86–1.00	0.055
Infrastructure	0.92	0.87–0.98	0.005
Education/research	0.91	0.83–1.00	0.047

CI, confidence interval; CSC, comprehensive stroke care; JCS, Japan Coma Scale; OR, odds ratio.
doi:10.1371/journal.pone.0096819.t008

hospital characteristics based on the recommended components of CSCs [2] on the in-hospital mortality of patients with acute ischemic and hemorrhagic stroke treated between April 1, 2010 and March 31, 2011. We found that the total CSC score was significantly associated with in-hospital mortality rates irrespective of stroke type after adjustment for age, sex, and initial level of consciousness according to the Japan Coma Scale. However, the subcategory scores that were significantly associated with in-hospital mortality differed among stroke type. Importantly, the association between total CSC scores and in-hospital mortality remained significant after adjustment for age; sex; initial level of consciousness according to the Japan Coma Scale; and incidence of hypertension, diabetes mellitus and hyperlipidemia for all types of stroke except SAH. These findings highlight the importance of CSC capabilities for optimal treatment of ischemic and hemorrhagic stroke and will enable health care professionals and policy makers to focus their efforts on improving specific aspects of CSC capabilities for different types of stroke.

Increasing attention has been given to defining the quality and value of health care through the reporting of process and outcome measures. Following the original proposal to establish CSCs [2], detailed metrics for measuring quality of care in CSCs have been reported [5]. The so-called "drip-and-ship" model has emerged as a paradigm for emergency departments that are able to diagnose acute ischemic stroke and administer intravenous (IV) recombinant t-PA (rt-PA) but lack the infrastructure to provide intensive monitoring for patients after rt-PA administration [15,16]. A recent study demonstrated that despite having more severe strokes on arrival at the CSC, transfer-in patients with acute ischemic stroke had in-hospital mortality similar to that of front door patients and were more likely to be discharged to rehabilitation. These findings lend support to the concept of regionalized stroke care and directing patients with greater disability to more advanced stroke centers [17]. At present, no official certification of stroke centers in Japan has been launched, and the current study indicates that patients with acute ischemic stroke or hemorrhagic stroke are being admitted on an emergent basis to hospitals with similar CSC total and subcategory scores.

In the present study, stroke severity was adjusted by baseline level of consciousness according to the Japan Coma Scale [10,11]. The Get With the Guidelines-Stroke (GWTG-Stroke) risk model was recently developed to predict in-hospital ischemic stroke mortality, suggesting that the National Institutes of Health Stroke Scale (NIHSS) score provides substantial incremental information on a patient's mortality risk [18], emphasizing the importance of adjustment of stroke severity to develop a hospital risk model for mortality [19]. Previous prospective multicenter study has demonstrated that the development of a decreased level of consciousness within the initial hours after stroke onset, as evaluated by a simple six-point scale, is a powerful independent predictor of mortality after a major ischemic stroke of the anterior vasculature [20]. In hemorrhagic stroke, the degree of impaired consciousness at admission was also included in the various proposed ICH scores to predict functional outcome and mortality [21,22]. This study demonstrated that the level of consciousness at admission, as measured by the Japan Coma Scale, is a powerful independent predictor of mortality after ischemic and hemorrhagic stroke. Determining an individual patient's risk of mortality at admission could improve clinical care by providing valuable information to patients and their family members and by identifying those at high risk for poor outcomes who may require more intensive resources.

Health care quality of CSCs in the present study was scored on the basis of the results of a questionnaire referring to 25 items originally recommended by the Brain Attack Coalition. Although there is now increasingly good evidence from initiatives like GWTG-Stroke [23] that a process based on the systematic collection and evaluation of stroke performance measures can

Table 9. The impact of subcategory CSC score on in-hospital mortality after subarachnoid hemorrhage adjusted by age, sex and JCS.

Component	OR	95% CI	P value
Personnel	0.91	0.84–0.98	0.016
Diagnostic techniques	1.01	0.92–1.11	0.896
Specific expertise	0.83	0.75–0.93	<0.001
Infrastructure	0.89	0.83–0.96	0.002
Education/research	0.84	0.75–0.95	0.005

CI, confidence interval; CSC, comprehensive stroke care; JCS, Japan Coma Scale; OR, odds ratio.
doi:10.1371/journal.pone.0096819.t009

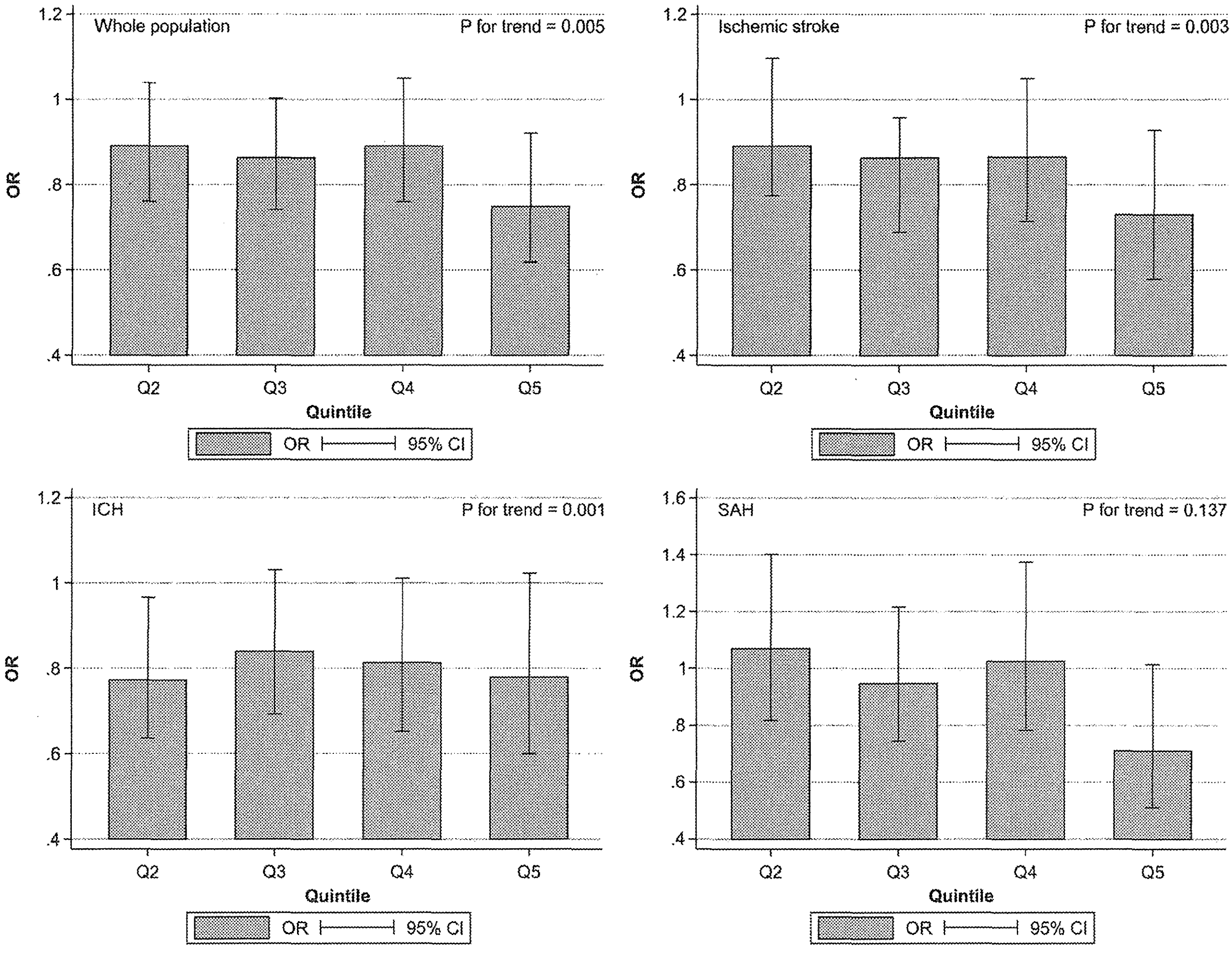

Figure 1. Associations between total comprehensive stroke care (CSC) scores separated into quintiles (Q1: 4–12, Q2: 13–14, Q3: 15–17, Q4: 18, Q5: 19–23) and in-hospital mortality of patients after all types of stroke (a), ischemic stroke (b), intracerebral hemorrhage (ICH) (c), and subarachnoid hemorrhage (SAH) (d), after adjustment for age and sex. Odds ratios (ORs) and 95% confidence intervals (CIs) of in-hospital mortality of each total CSC score quintile are depicted compared with that of Q1 as control.
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rapidly improve the quality of stroke care delivered by hospitals, current metrics are mostly limited to process measures that address the care of patients with ischemic stroke in acute hospital-based settings [4]. In addition, there is a pressing need to demonstrate a direct link between better adherence to stroke performance measures and improved patient-oriented outcomes [4,24].

One potential issue with the interpretation of this study could be the lack of a control group. Although there is currently no clear consensus regarding the recommended criteria for CSCs in Japan, the present study distinctly shows that the CSC scores widely distributed in Figure 1 and classified into quintiles were significantly associated with in-hospital mortality for all types of stroke; in fact, mortality after all types of stroke markedly decreased, for example, in ischemic stroke cases by about 40% in hospitals in the highest quintile compared with those in the lowest quintile.

In the present study, our questionnaire was primarily based on the American definition of CSCs. However, according to the definitions derived from a European survey of experts in the field [25], facilities that meet the criteria for CSCs should include the capability to conduct sophisticated monitoring, such as automated electrocardiography (ECG) monitoring at bedside and automated monitoring of pulse oximetry, in addition to the numerous aspects of care capability indexed by the American definition of CSCs used in this study. According to the European approach, to meet the criteria for CSCs, hospitals should have the availability of at least 80% of the components rated as absolutely necessary by at least 50% of experts who participated in the previous expert survey; moreover, these components must be present in each of 6 categories and include the 19 components rated as absolutely necessary by >75% of experts. Based on the present results and an additional ongoing study using a validation cohort in Japan, the criteria for the designation of CSCs in Japan should be determined after further thorough discussion among Japanese stroke experts.

The present study demonstrated the feasibility and impact of using nationwide discharge data with hierarchical logistic regression analysis to examine the random effects that vary among hospitals, as well as the fixed effects of CSC score and patient effects of age, sex, and level of consciousness. We used unique hospital ID in random-intercept hierarchical regression models to assess the association between CSC score and mortality, adjusting

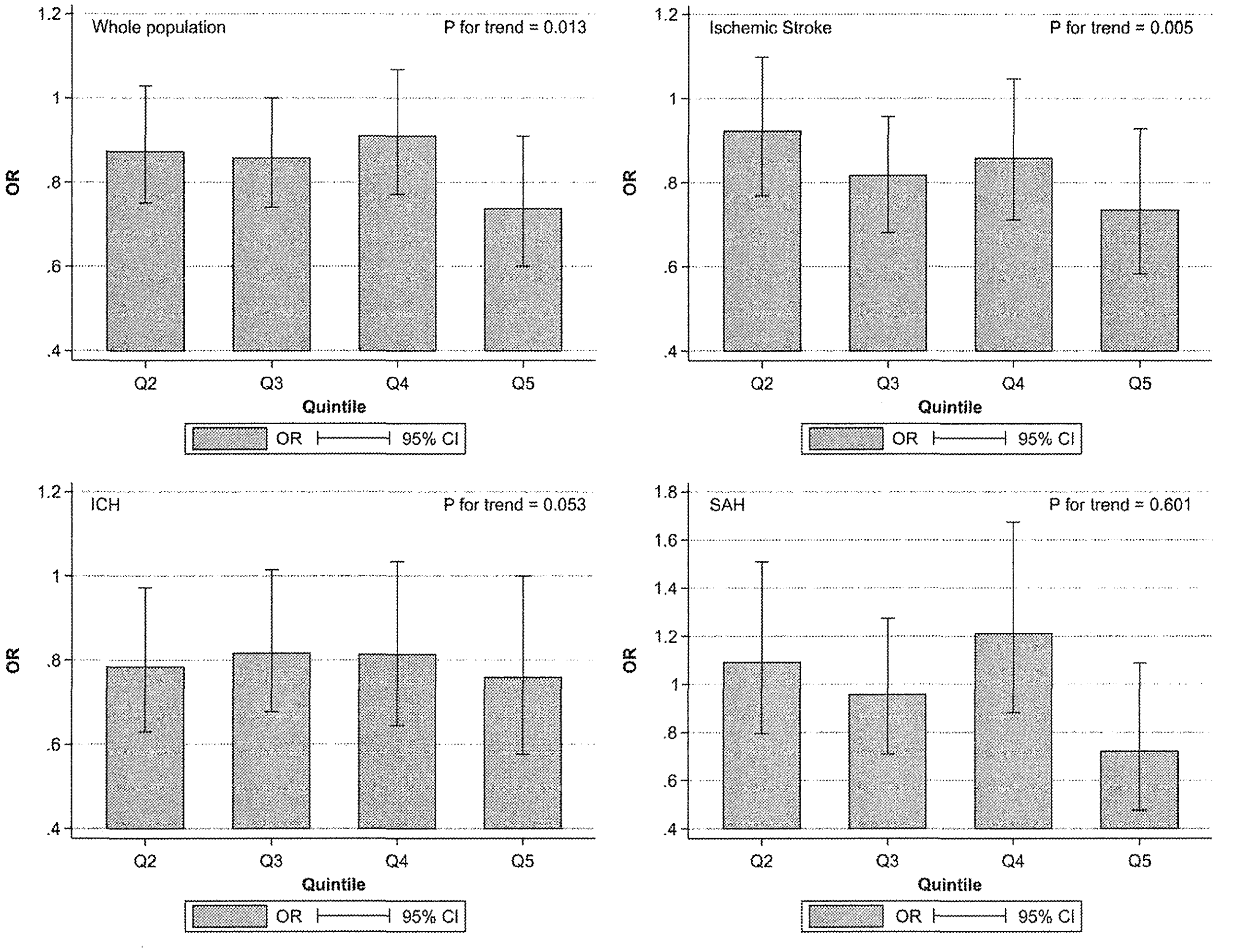

Figure 2. Associations between total comprehensive stroke care (CSC) scores separated into quintiles (Q1: 4–12, Q2: 13–14, Q3: 15–17, Q4: 18, Q5: 19–23) and in-hospital mortality of patients after all types of stroke (a), ischemic stroke (b), intracerebral hemorrhage (ICH) (c), and subarachnoid hemorrhage (SAH) (d), after adjustment for age; sex; initial level of consciousness; and incidence of hypertension, hyperlipidemia, and diabetes mellitus. Odds ratios (ORs) and 95% confidence intervals (CIs) of the in-hospital mortality of each total CSC score quintile are depicted compared with that of Q1 as control.
doi:10.1371/journal.pone.0096819.g002

for patient characteristics and the hospital where a patient was treated.

This model adjusts for hospital-level effects that arise from factors such as geographical location and ageing of the local population. After adjustment, we can isolate the pure CSC score effects on mortality by hospital, as discussed by Localio et al. [26]. If the CSC score is no longer significant after accounting for hospital-level variation, the differences in mortality can be assumed to arise from differences among hospitals. This approach enabled us to elucidate the impact of various CSC metrics on in-hospital mortality of patients with different stroke types. By expanding the scope of performance measures to include all types of stroke, the present study was able to direct links between specific recommended items of CSC capacities and in-hospital mortality after both hemorrhagic and ischemic stroke. While previous reports [7] showed that aspects of acute stroke care, such as admission to an SCU, the presence of an acute stroke team, and the organized stroke care index, were significantly associated with effects on in-hospital mortality after acute stroke, the present study clearly shows that the same is true for the CSC score based on the items recommended by the American Stroke Association.

Finally, one could argue that there really is no concept of 3/4 CSCs, but rather only CSCs or PSCs. In light of the existing evidence regarding the impact of the recommended CSC items on stroke outcomes, we advocate a CSC scoring system to examine the impact of availability of the recommended items on in-hospital mortality for all types of stroke. Considering the marked impact of the CSC score on outcome after all types of stroke, the differential impacts of CSC subcategory scores for different stroke types may make a single simple and effective CSC criterion unrealistic as a tool to produce a nationwide reduction in stroke mortality. In our opinion, it may be a more viable option to employ CSC scores in a more limited fashion, that is, to benchmark the state of care currently provided by medical centers treating stroke patients.

Limitations

First, the questionnaire used in this study is new and has not undergone pilot testing or systematic analysis; thus, its validity and reliability are uncertain. The current set of CSC score items does