17.8%, p = 0.0268, respectively) and office workers (27.1%, p < 0.001 and 12.2%, p = 0.004, respectively).

Relationship between burnout and workload, sleep duration, work experience and time spent for stroke care

Analysis of the scores indicated that the number of hours worked per week is positively associated with burnout severity, with the mean number of hours worked per week by physicians who were not burned out, mild to moderately burned out, and severely burned out found to be 64.3, 69.9, and 72.4 hours, respectively.(Table 1). Analysis of these data indicates that physicians who are burned out work a significantly greater number of hours per week compared to those who are not burned out (p < 0.001). In contrast, analysis of the data also indicates that sleep duration is inversely associated with burnout. The severity of burnout increases significantly as the number of hours slept per night decreases (p for trend <0.001). Likewise, number of years of experience was found to be inversely associated with severity of burnout. Specifically, the severity of burnout significantly increases as the number of years of experience decreases (p for trend < 0.001).

Thus, the study results indicate that a relatively greater workload per week, shorter sleep duration per night, and briefer work experience are all associated with increased prevalence of burnout and burnout severity. Figure 3a, which stratifies the data according to quartiles, indicates that the trend of increasing prevalence of burnout with an increasing number of

hours worked per week is statistically significant ($p < 0.001$). Confirming this trend, the age-and-sex-adjusted odds ratio (OR) for burnout was found to increase in the 4th quartile for number of hours worked approximately 2.4 times greater than that for those in the 1st quartile ($p < 0.001$). In contrast, burnout increased as the number of hours slept per night decreased (p for trend <0.001).(Figure 3b) Likewise, the OR of burnout was found to be inversely associated with number of years of experience. ($p < 0.001$).(Figure 3C) Further analysis indicates that these associations hold for both burned-out and severely burned-out physicians (Appendix Figure 1).

The effect of time spent for stroke care is mildly associated with burnout. (Figure 3 d) Those who spent 75% of their time for stroke care were found to be 47.7% burned out, while those who spent less than 25% were 37.0% burned out. The trend of increasing prevalence of burnout with an increasing proportion worked for stroke care is statistically significant ($p = 0.023$).

Other significant predictors of burnout

Figure 4a shows the predictors that remained in the final prediction model for burnout after performing forward selection. These predictors are number of hours worked per week, number of hours slept per night, number of day offs per week, number of after-hours calls per week, number of years of experience, and income. For neurosurgeons, the number of t-PA cases treated per year was also found to increase the risk of burnout by 27%. (Figure 4b). The

factors associated with burnout are similar between all stroke providers and the subgroup of stroke providers that are neurosurgeons. Furthermore, these associations were found to be robust such that they held when stricter criteria for burnout were applied to the model (Appendix Tables 1).

The interaction term between working hours v.s. time slept, and term between working hours v.s. experience year were insignificant (p=0.671 and p=0.73, respectively). Neither combination of interaction terms among best predictor variables was statistically significant.

Institutional Background, Quality of Care and Burnout.

The association of physicians working in teaching hospitals or CSC between the structure aspects of stroke care centers and burnout were investigated. After adjusting by age, working hours, and sleeping hours, those who were in the institutions for thrombolysis therapy certified by Japanese stroke society were slightly increased the risk of burnout. On the other hand, Those who were in the institutes for hyper acute stroke care certified by government tended to be less burnout. (Table 2). Number of Beds, existence of stroke care unit, existence of 24hour MRI/CT, mean values of death rate within 24 hours, mean values of death rate within 30 days, mean values of modified ranking scale at 30 days were not associated with burnout.

Discussion

This nation-wide survey of Japanese physicians working in stroke care revealed that this population experiences burnout at a rate considerably higher than that of the general population of Japanese workers.

The primary hypothesis examined in this study is that the most important risk factor for burnout among physicians working in stroke care is heavy workload, more specifically working an excessive number of hours per week. Whereas the mean number of hours worked per week by the study population was 66.3 hours, those by the general Japanese population was 45.8 hours in 2010.[17] These findings accord with previous research for general population demonstrating that working an excessive number of hours is a risk factor for burnout[1] and fatigue.[18] The study participants work considerably more hours per week and they are at greater risk of burnout.

While this association between high rates of burnout and long working hours accords with a study of U.S physicians[2] and U.S surgeons,[2, 3] neither of these studies investigated the factors quantitatively by performing stratification by quartile. Other previous studies focused on the prevalence of burnout itself or the psychosocial background of the participants and did not discuss this point[19-21].

The results of the present study also may indicate that sleep duration is associated with burnout. One prospective study reported that insomnia increased emotional exhaustion 3-fold.[22] In one prospective observational study, less than 6 hour sleep caused the risk of

clinical burnout[23]. These support our finding and less sleep is the potential risk factors for burnout. Among physicians, working long hours in addition to taking frequent after-hours calls may decrease sleep duration and cause sleep fragmentation, may increase the risk of burnout. Thus, sleep duration is another important and potential modifiable factor to consider in the prevention of burnout.

Furthermore, interventions aimed at reducing working hours and increasing sleep duration have been found to reduce the prevalence of burnout among physicians. Restriction of working hours in medical residency reduced the mean working hours of 7.5 hours and reduced burnout from 74% to 56%.[24] One intervention that limited the number of hours increase sleep duration and reduce medical errors by more than 50%.[25] All the findings may indicate that we should start the study whether the reduction of working hours and/or increase of sleep reduce the burnout among physicians in stroke care.

In addition, the burden of being responsible for emergency admission may have been associated with feelings of being 'overwhelmed',[26] and physicians working in emergency medicine have been found to experience the highest rate of burnout among all U.S physicians.[2] This is compatible with our study population that t-PA cases, which are very urgent, are associated with burnout for neurosurgeons. From the analysis of backgrounds of institutes, the officially credited institutes for thrombolysis therapy are associated with slightly increased the risk of burnout. But, simultaneously, the official credited centers for

hyper-acute stroke care centers which satisfied the criteria of CSC by Joint Commissions reduced the risk of stroke care approximately 21%. This result might suggest sufficient staffing can reduce burnout, even in intensive care situations.

This study had several strengths that contributed to the reliability and validity of the findings. First, it was the first large study to show an association between physician burnout and workload in Asian countries. As the rate of burnout among the physicians in this study was found to be similar to that among physicians in western countries,[2, 3, 27, 28] burnout appears to be a common phenomenon among physicians in both the East and the West.

Second, this study examined a sufficiently large sample of physicians with a homogenous training and practice background and varying workloads. In contrast, most previous studies were conducted in a single center using a sample size insufficiently large to identify an association between burnout and workload,[29, 30] with even studies using a relatively large sample identifying no association.[27] However, these findings may be attributed to the fact that all of the participants in these studies worked relatively long hours, preventing comparison of the impact of workload among them.

Third, this study used a stricter set of criteria termed 'exhaustion+1', which is considered more appropriate for assessment of burnout than those used in past studies.

Finally, this study demonstrated that the risk of burnout is inversely associated with the number of years of experience, as had several previous studies.[2, 3] This phenomenon is likely

due to the fact that promotion to an administrative position after acquiring a certain number of years of experience leads to a decreased clinical workload. It may also reflect a selection bias in those who are more severely burned out quit practice earlier in their carrier. Recent studies suggest that burnout may influence quality of care and lead to early retirement.[31]

In addition, we found some association between burnout and those who in the institutions credited for hyper acute stroke care by Japanese government, which satisfied the components of CSC by the Joint Commissions. This may suggest the centralization of stroke care in CSC helps to reduce burnout among stroke care. However, the sample size is limited for 59.4% responders and further study is needed for this issues.

Despite these strengths, this study also faced several limitations. First, this study used a cross-sectional design, and was thus unable to determine the existence of any direct causal relationships. Second, the percentage of female physicians examined in this study was smaller than that of the general population of female physicians in Japan, which was 18.9% of all physicians in 2010.[22] Therefore, the findings may not be generalizable to female physicians. Nevertheless, no differences were observed between the male and female physicians in the study sample regarding prevalence of burnout and related factors.

Third, selection bias may have been a limitation, as physicians who were burned out may have been more or less likely to complete the survey. However, the prevalence of burnout in this study was found to be similar to that of other studies for physicians[2, 3, 32]. although the

response rate in these studies was higher than our study except for Shanafelt's, which response rate was 26.1%. Nevertheless, several cross-sectional investigations have failed to identify significant differences between responding and nonresponding physicians[33]. We found no statistically significant differences for age, sex, and specialty (neurologist vs neurosurgeon) among early responders compared with late responders as Shanafelt et al conducted[2]. In addition, there was no statistical difference between the address of responders and those of non-responders. We also pointed out that the survey was not supposed to be answered by all the specialists. It is answered by the physicians working for stroke care only, but from the another survey for Japanese brain surgeon, only 40% of brain surgeon, is working for stroke care in Japan. If this proportion holds, the estimated response rate of target population is approximately 61% and quite similar or higher to the response rate of former physician burnout studies.

In conclusion, the results of this study suggest that burnout is highly prevalent among Japanese physicians working in stroke care. The risk factors for burnout appear to be relatively fewer years of work experience, longer working hours per week, and shorter sleep duration per night. Additional prospective research is now needed to assist in the development of interventions to address this pressing problem.

Acknowledgements: The authors thank all the participants for completing the survey, Dr. Manabu Hasegawa of the Ministry of Labor, Welfare, and Health of Japan for his cooperation with and designing of this study, and all the partners in the J-ASPECT study.

The following are members of J-ASPECTS Study Group (the nationwide analysis of emergency medical services and Acute Stroke care capacity and interventions for Proper dEsignation of stroke CenTers in Japan): Koji Iihara,MD,PhD (project leader), Kunihiro Nishimura, MD,PhD, Fumiaki Nakamura, MD,PhD., Misa Takegami,RN.PhD, Schunichi Fukuhara, MD,PhD,Jyoji Nakagawara, MD,PhD, Kuniaki Ogasawara, MD,PhD, Junichi Ono, MD,PhD,Yoshiaki Shiokawa, MD,PhD,Toru Aruga, MD,PhD, Shigeru Miyachi, MD,PhD, Izumi Nagata, MD,PhD, Kazunori Toyoda, MD,PhD, Shinya Matsuda, MD,PhD, Hiroharu Kataoka, MD,PhD,Akiko Kada,PhD,Yoshihiro Miyamoto, MD,PhD, Kazuyo Kitaoka.RN,PhD,

Funding sources: The study has been supported by grants from Health Labor Sciences Research Grant for J-ASPECT task force. (22-cardivascular –general-001, Principal Investigator; Koji Iihara) of Ministry of Health, Labor and Welfare, Japan. The authors' institutions had no role in the design and conduct of the study; the collection, management, analysis, and interpretation of the data; or the preparation, review, or approval of the manuscript.

Disclosures: All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare support from the Ministry of Health, Labor and Welfare. Japan; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributors: KN designed data collection tools, monitored data collection for the whole study, wrote the statistical analysis plan, cleaned and analysed the data, and drafted and revised the paper. KN is guarantor. KK and SF wrote background and drafted and revised the paper. PB analysed the data and drafted and revised the paper. AK wrote the statistical analysis plan, monitored data collection for the whole study, and revised the draft paper. FN, MT and KI designed survey questionnaires, and revised the draft paper. KI initiated the collaborative project, analysed the data, and drafted and revised the paper. All members of J-ASPECT designed the trial. JN, KO, JO, YS, TA, SM, IN, KT, SM, HK, YM validated the survey questions from the view of physicians and revised the draft paper.

Figure Legends

Figure 1. Flow chart of sample selection process

Figure 2. Prevalence of burnout among Japanese physicians, office workers, and civil servants

Figure 3. Relationship between prevalence of burnout and workload, sleep duration, and work experience

1Q–4Q: 1st to 4th quartile; 95% confidence interval (CI). Odds ratios adjusted for sex and age were obtained by logistic regression analysis. As number of years of experience was approximately proportional to age, age was omitted from the adjustment. The 1st quartile served as a reference for workload and sleep duration.

Figure 4. Predictors for burnout at 95% confidence intervals

(a) Age- and sex-adjusted predictors of burnout; (b). Best predictors of burnout identified by multivariate logistic regression; (c) Best predictors for neurosurgeons in multivariate logistic regression analysis.

Table 1. Personal characteristics of study sample by burnout status (N = 2,635)

	Not burned out	*Mild to moderately Burned out*	*Severely burned out*	*P for trend*
N	**1,562**	**505**	**568**	
Percentage of sample	**59.3**	**19.2**	**21.6**	
Male (%)	**92.0**	**93.1**	**90.7**	**0.469**
Age (years)	**48.2(9.4)**	**46.3 (8.9)**	**45.1(8.4)**	**<0.001**
MBI-GS scores				
Exhaustion	**2.06 (0.98)**	**3.72(1.12)**	**4.89 (0.58)**	**<0.001**
Cynicism (depersonalization)	**1.12 (0.73)**	**2.69 (1.16)**	**3.77 (1.23)**	**<0.001**
Personal accomplishment	**4.36 (1.61)**	**4.17 (1.48)**	**3.41 (1.58)**	**<0.001**
Number of hours slept/night	**6.07 (1.15)**	**5.88 (0.94)**	**5.63 (0.94)**	**<0.001**
Number of hours worked/week	**64.3 (15.7)**	**66.9 (16.1)**	**72.3 (16.6)**	**<0.001**
Number of day offs/week	**1.19 (0.64)**	**1.10 (0.66)**	**0.94 (0.59)**	**<0.001**
Number of nightshifts/month	**2.62 (2.80)**	**3.01 (2.91)**	**3.67 (3.64)**	**<0.001**
Number of after-hours calls/week	**1.69 (2.92)**	**2.14 (3.15)**	**2.92 (3.84)**	**<0.001**
Percentage of time spent in stroke care	**44.4 (25.9)**	**47.3 (26.6)**	**48.5 (26.4)**	**<0.001**
Number of t-PA cases/year	**2.06 (3.20)**	**2.38 (3.58)**	**2.68 (3.86)**	**<0.001**
Number of patients under care	**9.11 (6.94)**	**9.81 (6.65)**	**10.51 (6.62)**	**<0.001**
Number of years of experience	**22.6 (9.28)**	**20.8 (8.84)**	**19.6 (8.36)**	**<0.001**
Income (10,000 Yen)	**1488.0 (418.1)**	**1446.0 394.0)**	**1376.8 (418.7)**	**<0.001**
(1,000 Euro)	**(139.0)**	**(131.5**	**(128.5)**	
Married (%)	**82.8**	**83.5**	**76.6**	**0.003**
Children <23 y.o. (%)	**67.9**	**68.5**	**70.3**	**0.281**
Divorced (%)	**1.86**	**1.02**	**2.70**	**0.362**

Values are means (standard deviations) or numbers of participants (percentages). t-PA, tissue plasminogen Values are means (standard deviations) or numbers of participants (percentages). t-PA, tissue plasminogen activator;10,000 Yen ≒ 10,000 Dallors.

Table 2. Best predictors in multivariate logistic regression for burnout from institutional backgrounds

Predictors	Odds Ratio	P-value	95% CI
Hyper acute stroke care centers	0.79	0.089	0.61-1.04
Certified institutions for thrombolysis therapy	1.08	0.037	1.08-1.16
Number of experience years	0.73	<0.001	0.64-0.84
Number of hours slept/night	0.78	<0.001	0.68-0.88
Number of hours worked/week	1.11	0.015	1.02-1.21

Forward section with Akaike information criterion (AIC) was conducted to select the best prediction model.

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Figure 1 Flow of participants in this study

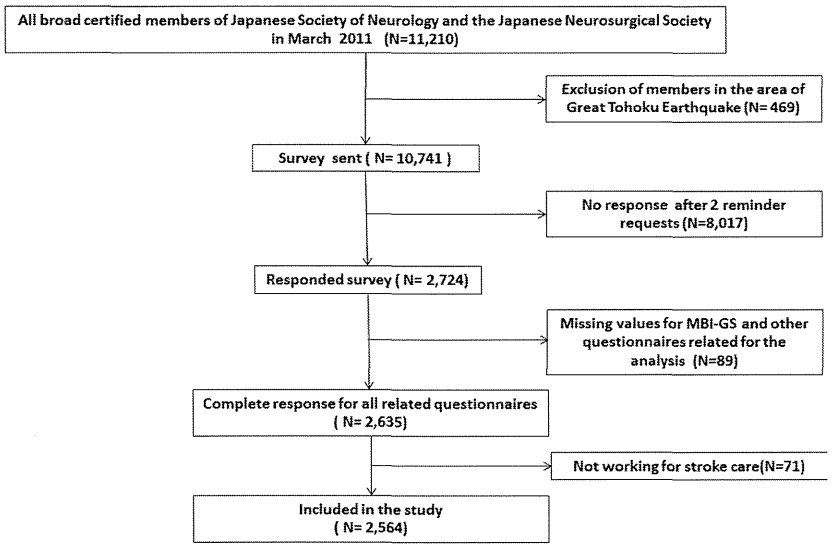
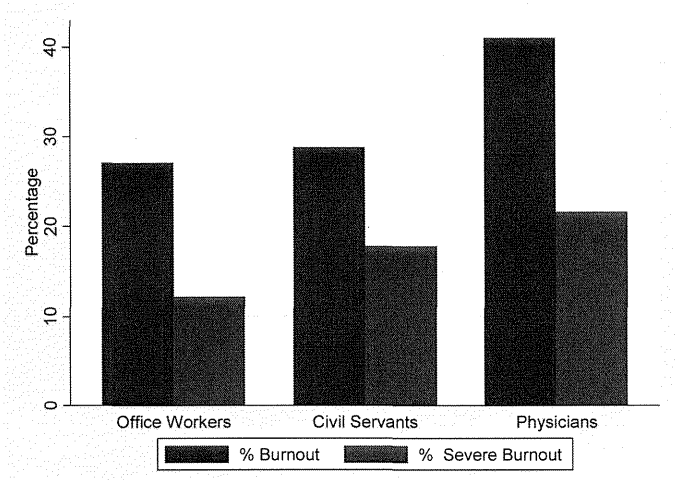
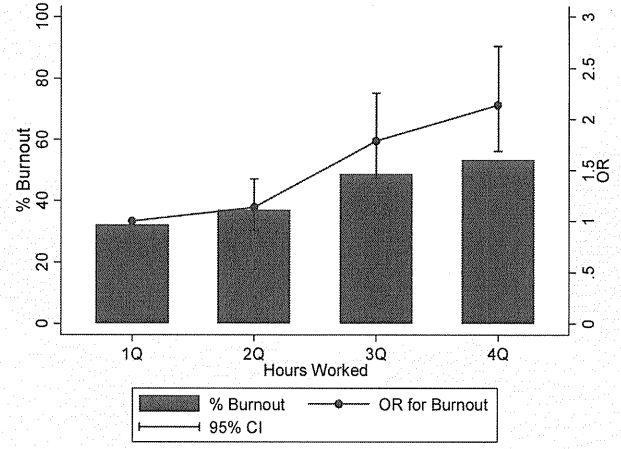


Figure 2 Prevalence of Burnout among Physicians and Non-Physicians

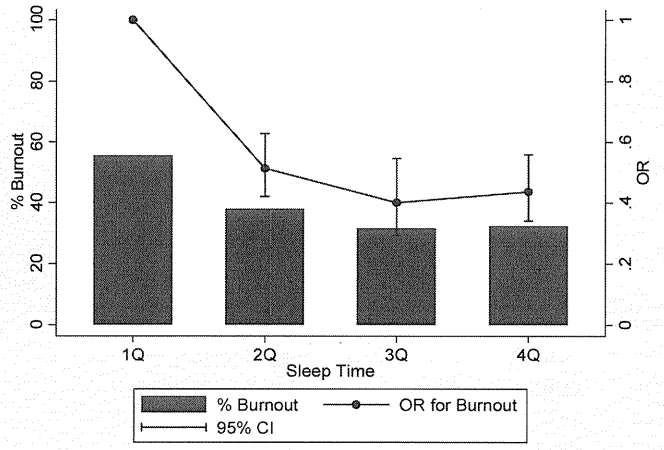


Prevalence of burnout was calculated for stroke care physicians (N=2,635), civil servants (N=751) and office workers (N=2,843). Percentage of Burnout was determined by Maslash Burnout Inventory-General Survey (MBI-GS). Prevalence of Burnout among stroke care physicians were significantly higher than those of civil servants and office workers. (40.7% versus 28.8%, versus 27.1%, respectively and both p <0.0001.) This association also hold for sever burnout. (21.6% versus 17.8%, P=0.0268 and versus12.2%, P<0.001, *respectively*)

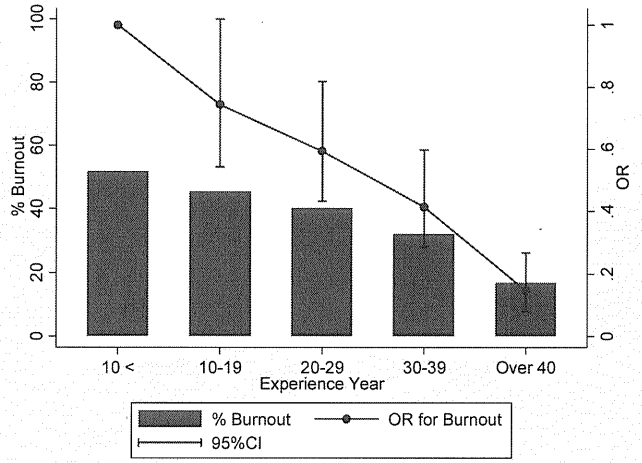
Figure 3 Association between burnout and working hours, sleep time ,experience hours and time spent for stroke scare.



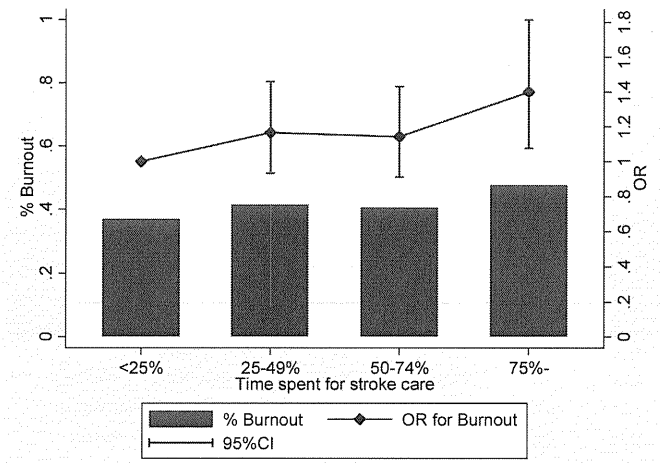
3(a) Hours Worked



3(b) Sleep Time



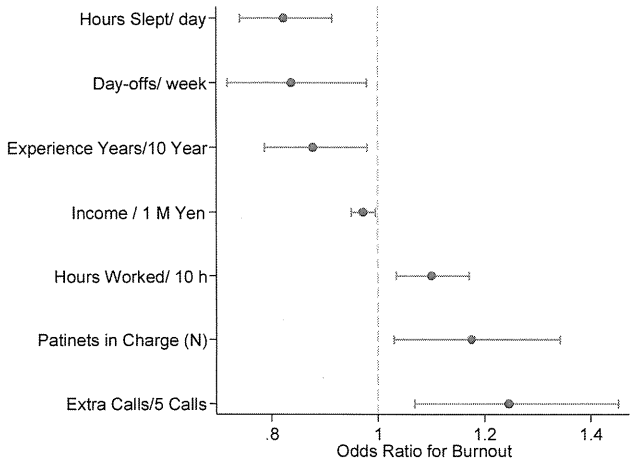
3(c) Experience Years



3(d) Time Spent for Stroke Care

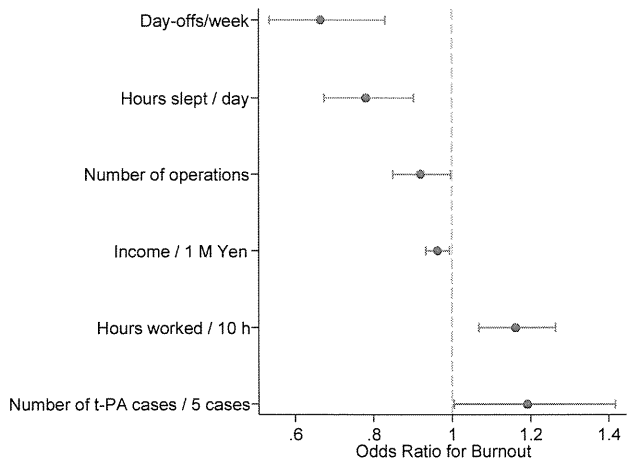
1Q-4Q, first to forth quartile; 95% CI, 95% confidence interval. Odds ratios adjusted for sex and age were obtained from logistic regression analysis. Experience years were approximately proportional to age and age was omitted for the adjustment. For working hours and sleeping hours, first quartiles were considered as reference.

Figure 4 Best Predictors in multivariate logistic regression analysis for burnout with 95% Confidence Intervals



Predictors	*Odds Ratio*	*p-value*	*95% CI*	
Hours Slept/ day	0.82	0.0003	0.74	0.91
Day-offs/ week	0.84	0.0259	0.72	0.98
Experience Years/10 year	0.88	0.0204	0.79	0.98
Income / 1 M Yen	0.97	0.0172	0.95	1.00
Hours Worked/ 10 h	1.10	0.0024	1.03	1.17
Patients in Charge (N)	1.18	0.0166	1.03	1.34
Extra Calls/ 5 Calls	1.25	0.0049	1.07	1.45

4(a) Best predictors for whole study population



Predictors	*Odds Ratio*	*p-value*	*95% CI*	
Day-Offs/week	0.67	0.0003	0.53	0.83
Hours Slept / day	0.78	0.0008	0.68	0.90
Number of operations	0.92	0.0416	0.85	1.00
Income / 1 M Yen	0.96	0.0193	0.93	0.99
Hours worked / 10 h	1.16	0.0004	1.07	1.26
Number of t-PA cases / 5 cases	1.19	0.0449	1.00	1.42

4(b) Best predictors for neurosurgeons

Sleep time; sleep time/day, Hours worked ;hours worked /10 incremental hours, Number of holidays; number of holidays/week, Number of nightshifts; number of nightshifts/ month Number of extra calls ;number of extra calls after hours / 5 incremental calls/week, % time for spent stroke ;% time for stroke care/10% incremental of time, Number of t-PA cases; number of t-PA cases/ 5 incremental cases / year Number of patients; number of patients in charge/10

incremental patients, Experience Year; experience Years/ 10 incremental years*, Income; income/ 1 Million Yen. Odds ratios adjusted for sex and age were obtained from complementary logistic regression analysis.

t-PA , tissue plasminogen activator ;1 Million Yen ≒12, 000 U.S. $,*Experience years were approximately proportional to age and age was omitted for the adjustment.

4(a) Significant predictors in table 2 were considered potential predictors. Forward section with Bayesian information criterion (BIC) was conducted to select the best prediction model.

4(b) Analyzed for neruosurgeon only (N=1,673). Predictors specific for surgeons, number of operation, number of emergency operation, and number of operation for stroke were included.

Appendix Table 1 Best predictors in multivariate logistic regression for sever burnout

Whole study population				*Neurosurgeons*			
Predictors	Odds Ratio	P-value	95% CI	Predictors	Odds Ratio	P-value	95% CI
Sleep time/ day	0.78	<0.001	0.68-0.88	Sleep time/ day	0.80	0.010	0.67-0.95
10 Hours increase of hours worked/ week	1.17	<0.001	1.08-1.26	Hours worked/ week	1.22	<0.001	1.03-1.12
Number of holidays/ week	0.74	0.003	0.61-0.90	Holidays/ week	0.69	0.006	0.53-0.90
Number of extra calls after hours/5 incremental calls/ week	1.22	<0.001	1.04-1.44	Number of extra calls after hours/5 calls/ week	1.32	0.007	1.08-1.60
Increase of 10 patients in charge	1.22	0.016	1.04-1.44	Number of Operation	0.88	0.007	0.80-0.97
Income/1 million Yen (Income/ $12500)	0.95	<0.001	0.93-0.98	Income/1 million Yen (Income/ $12500)	0.96	0.019	0.92-0.99

Forward section with Akaike information criterion (AIC) was conducted to select the best prediction model.