

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, burned out, and severely burned out found to be 64.3, 69.9, and 72.4 hours, respectively. 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. Specifically, physicians who were not burned out, burned out, and severely burned out were found to sleep a mean of 6.07, 5.74, and 5.62 hours per night, respectively, indicating that 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, physicians who were not burned out, burned out, and severely burned out were found to have worked a mean of 22.6, 20.1, and 19.6 years, respectively, indicating that the severity of burnout significantly increases as the number of years of experience decreases (p for trend < 0.001 ; Table 1).

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. As shown in Figure 3a, which stratifies the data according to quartiles, the prevalence of burnout among the physicians in the 1st to 4th quartile of number

of hours worked per week was found to be 32.3%, 37.1%, 48.8%, and 53.6%, respectively. Analysis of these data 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 prevalence ratio (PR) for burnout was found to increase as the number of hours worked per week increases, with the risk for physicians in the 4th quartile for number of hours worked (over 90 hours/week) approximately 2.1 times greater than that for those in the 1st quartile (40–55 hours/week; PR = 2.14; 95% confidence interval [CI], 1.69 to 2.71, $p < 0.001$). In contrast, the age-and-sex-adjusted PR for burnout was found to increase as the number of hours slept per night decreased, with the percentage of burnout among physicians in 1st to 4th quartiles of sleep duration found to be 55.6%, 38.1%, 31.7%, and 32.4%, respectively (p for trend < 0.001). As shown in Figure 3b, the prevalence of burnout among physicians in the 4th quartile of number of hours slept per night (6.7–9 hours/night) was approximately 48% lower than that of physicians in the 1st quartile (3–5 hours/night; PR = 0.52; 95% CI, 0.43 to 0.63, $p < 0.001$). Likewise, the prevalence of burnout was found to be inversely associated with number of years of experience. As shown in Figure 3c, the prevalence of burnout among physicians in 4th quartile (more than 40 years of experience), which was found to be 18.7%, was approximately 78% lower than that of physicians in the 1st quartile (less than 10 years of experience), which was found to be 52.3% (PR = 0.22; 95% CI, 0.13 to 0.38, $p < 0.001$). In accordance, the prevalence of burnout

among physicians in the 2nd quartile (30–39 years of experience) was found to be 31.6%, a prevalence between that of the 1st and 4th quartiles (PR = 0.49; 95% CI, 0.37 to 0.65, $p < 0.001$). Further analysis indicates that number of hours worked per week and the number of hours slept per night are both inversely associated with the number of years of experience (Appendix Table 1) and that these associations hold for both burned-out and severely burned-out physicians (Appendix Figure 1).

Other significant predictors of burnout

Other personal and professional variables found to be significantly related to the prevalence of burnout are number of holidays per week, number of on-duty nights per month, number of after-hours calls per week, number of t-PA cases treated per year, percentage of time spent providing stroke care, and number of patients under charge (Table 1). The results of complementary log–log regression analysis adjusted for age and sex also revealed that the factors associated with workload include number of holidays per week, number of on-duty nights per month, number of after-hours calls per week, number of t-PA cases treated per year, and number of patients under charge (Figure 4a).

Figure 4b shows the predictors that remained in the final prediction model for burnout after performing forward selection using the BIC. These predictors are number of hours worked per week (PR = 1.08/10 incremental hours; 95% CI, 1.03 to 1.13), number of hours slept per

night (PR = 0.86; 95% CI, 0.80 to 0.93), number of holidays per week (PR = 0.86; 95% CI, 0.80 to 0.93), number of after-hours calls per week (PR = 1.20/10 incremental calls; 95% CI, 1.02 to 1.40), number of years of experience (PR = 0.90/10 incremental years; 95% CI, 0.83 to 0.98), number of patients under charge (PR = 1.13/10 incremental patients; 95% CI 1.02 to 1.35), and income (PR = 0.97/1 million incremental Yen, approximately 9,350 Euro; 95% CI, 0.96 to 0.99). For neurosurgeons, the number of t-PA cases treated per year was also found to increase the risk of burnout by 15% (PR = 1.15/5 incremental treatments; 95% CI, 1.03 to 1.29). The significant predictors shown in Figure 4b, number of hours slept, number of holidays, income and hours worked were also found to be significant (Figure 4c). Furthermore, these associations were found to be robust such that they held when stricter criteria for burnout were applied to the model (Appendix Tables 2 and 3).

Determinants of workload and sleep duration

Table 2 shows the results of multivariate linear regression analysis to identify the predictors of number of hours worked per week and slept per night. As can be observed, the number of hours worked per week was found to be proportional to the number of night shifts worked per week ($\beta = 1.12$, $p < 0.001$), number of extra after-hours calls per week ($\beta = 0.97$, $p < 0.001$), number of t-PA cases per year ($\beta = 0.60$, $p < 0.001$) but inversely proportional to female sex ($\beta = -7.05$, $p < 0.001$) and number of years of experience ($\beta = -0.31$, $p < 0.001$). Moreover, number of hours slept per night was found to be inversely proportional to number of hours

worked per week ($\beta = -0.018, p < 0.001$) and numbers of after-hours calls per week ($\beta = -0.027, p < 0.001$).

For neurosurgeons, the number of hours worked per week was also found to be proportional to both the number of emergency operations performed per year ($\beta = 2.02, p = 0.002$) and the number of stroke-related operations performed per year ($\beta = 1.41, p = 0.002$). The number of hours slept per night was again found to be proportional to the number of hours worked per week and the numbers of after-hour calls per week. No interaction term between predictors in GLM model showed statistical significance.

Discussion

This nation-wide survey of Japanese physicians working in stroke care produced several significant findings regarding this population that have important implications for health care. Specifically, the findings indicate that this population (1) experiences burnout at a rate considerably higher than that of the general population of Japanese workers and (2) tends to experience a low QOL and symptoms of depression. The findings also indicate that among the physicians in this population, those who work relatively more hours per week, sleep fewer hours per night, have fewer holidays per week, and have fewer years of experience are at greater risk of burnout. In addition, factors associated with off-schedule work, such as number of night shifts per week, number of after-hours calls per week, and number of

emergency cases treated (number of t-PA cases treated and emergency and stroke-related operations performed) per year were found to be directly related to the number of hours worked per week and indirectly related to prevalence of burnout.

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, the mean number of hours worked by the general Japanese population was 45.8 hours in 2010,²⁴ with only 12% of non-agricultural employees working a mean of 60 or more hours per week.²⁵ These findings accord with previous research demonstrating that working an excessive number of hours is a risk factor for burnout¹ and fatigue.²⁶ As the study participants work considerably more hours per week than the general population, they are at greater risk of burnout, as shown in Figure 2, which clearly illustrates the trend of increased rates of burnout among the study population with increases in the number of working hours. Thus, working a decreased number of hours worked per week, which has been associated with higher job satisfaction among physicians,²⁷ may prevent burnout.

As the results of all analyses indicated that number of hours worked per week is a strong and robust predictor, it can be concluded that the difference in the number of working hours per week between the study population and the general population of workers largely

explains the difference in their rates of burnout. While this association between high rates of burnout and long working hours accords with a study of U.S physicians² 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 participants²⁸⁻³⁰ rather than the relationship between burnout and number of working hours, sleep duration, and risk factors related to specific practice patterns.

The results of the present study also indicate that sleep duration is strongly associated with burnout, with number of hours slept per night found to be a robust estimator of burnout in all analyses performed. Burnout has been associated with generally poor sleep as well as increased daytime sleepiness and fatigue,³¹ with the polysomnography results of burned-out patients observed to indicate pronounced sleepiness and mental fatigue.³² One prospective study reported that insomnia increased emotional exhaustion 3-fold,³³ while another study identified a higher prevalence of depressive disorder among patients who slept relatively few hours.³⁴ As the physicians in this study slept a mean of 5.94 hours per night, it is unsurprising that approximately 2/3 were found to have symptoms of mild depression. As shown in Table 2, relatively short sleep duration was also found to be related to relatively long working hours. Among physicians, working long hours in addition to taking frequent after-hours calls may decrease sleep duration and cause sleep fragmentation, increasing the risk of burnout. Thus,

sleep duration is another important and potential modifiable factor to consider in the prevention of burnout.

Interventions aimed at reducing working hours and increasing sleep duration have been found to reduce the prevalence of burnout among physicians. One intervention that limited the number of hours scheduled for interns working in the ICU was found to significantly reduce working hours, increase sleep duration and reduce medical errors by more than 50%.³⁵

Although one trial study that limited the number of hours for residents to 80 per week³⁶ found no reduction in the prevalence of burnout, 80 hours is an excessive number of hours, and trial studies further limiting the number of working hours should therefore be conducted.

Interestingly, providing sabbaticals to nurses has been found to be cost effective to reduce burnout among nurses, and should be considered for physicians.³⁷ All the findings indicate that the Japanese Government should set national policies aiming to reduce fatigue and sleepiness to treat burnout among physicians working in stroke care. We need prospective study of stroke-care physicians with less than 10 years of experience, who are at higher risk of burnout; examining the means of reducing physician workload to reduce burnout, such as by developing and examining programs whereby physicians work together in the comprehensive stroke centers. Effect on quality of care for stroke patients also should be examined.

This study had several strengths that contributed to the reliability and validity of the findings

and allows it to contribute to the medical literature. 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 38 39} burnout appears to be a common phenomenon among physicians in both the East and the West. Second, this study confirmed the results of the study by Shanafelt et al., the first study to identify a higher prevalence of burnout among physicians compared to the general population of Japanese workers,² by validating their results in a different population. Specifically, whereas the response rate (26.7%) and sample size (N = 3,442) of their study were similar to those of this study, Shanafelt et al. focused on the entire population of physicians while this study focused on physicians within one specialty. As such, this study was unique in allowing for analysis of specific practice patterns among a specific population.

Third, 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 centre using a sample size insufficiently large to identify an association between burnout and workload,^{40 41} with even studies using a relatively large sample identifying no association.³⁸ 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. By examining a sufficiently large sample of physicians

with a homogenous training and practice background but with varying workloads, this study was able to identify clear associations among workload, sleep duration and burnout. This certified the generalizability of our work for Japanese stroke care physicians.

Fourth, to the best of our knowledge, this was the first study to examine and identify a relationship between physician burnout and factors related to off-hour workload and emergency treatment of stroke cases. As shown in Table 2, the number of hours worked per week was found to be proportional to the off-hour-related factors of number of nightshifts worked per week and number of after-hours calls per week, as well as the emergency-treatment-related factors of number of t-PA cases treated and number of emergency and stroke operations performed per year. These findings suggest that providing emergency and off-hour care to stroke patients is directly related to workload and sleep duration, and thus indirectly related to burnout. In accordance with these findings, the burden of being responsible for emergency admission has been associated with feelings of being ‘overwhelmed’,⁴² and physicians working in emergency medicine have been found to experience the highest rate of burnout among all U.S physicians.²

Fifth, 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. The predictors of burnout in conventional criteria for burnout is robustly predicted the more severe burnout status. This certified that the predictors of burnout in our study have strong and robust

association with burnout, even when different burnout criteria were applied for the diagnosis.

Sixth, compared to the use of the OR in previous studies, the use of the PR by GLM analysis in this study provided for a more conservative estimation of values and greater support that the results are robust.

Finally, this study demonstrated that the prevalence of burnout is inversely associated with the number of years of experience, as had several previous studies,^{2,3} as well as the number of hours slept per night. 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 (Appendix Table 1). Appendix Figure 2 summarizes all of the associations identified among workload, sleep duration, practice patterns, and burnout in this study.

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. Thus, future studies should employ a prospective longitudinal design to confirm the relationships identified between off-work-related factors and sleep duration among physicians providing stroke care. 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 2010.³³ 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, as the prevalence of burnout in this study was found to be similar to that of other studies of physicians, the magnitude of selection bias, if any, was likely minimal.

In conclusion, the results of this study indicate that burnout is highly prevalent among Japanese physicians working in stroke care and more prevalent among this population than the general population of Japanese workers. The most important 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 personal, organizational and societal interventions to address this pressing problem.

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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.

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