Recent Declining Trend of Incidence Rate of Subarachnoid Hemorrhage in Shimane, Japan: The Japan Incidence of Subarachnoid Hemorrhage (JIS) Study

Shingo MATSUDA,1 Fusao IKAWA,1,2 Toshikazu HIDAKA,1 Shuhei YAMAGUCHI,3 Tetsuji INAGAWA,4 Nobutaka HORIE,2 Kaoru KURISU,2,5 Yasuhiko AKIYAMA,6 Yoshihito GOTO,7 Takeo NAKAYAMA,6 Hitoshi FUKUDA,9 Tetsuya UEBA,9 Masahiro SASAKI,10 Tatsuya ISHIKAWA,10 Norihiro SHIMAMURA,11 Hiroki OHKUMA,11 and JIS study group

1Department of Neurosurgery, Shimane Prefectural Central Hospital, Izumo, Shimane, Japan
2Department of Neurosurgery, Graduate School of Biomedical and Health Sciences, Hiroshima University, Hiroshima, Hiroshima, Japan
3Department of Neurology, Hospital Bureau of Shimane Prefecture, Izumo, Shimane, Japan
4Department of Neurosurgery, Araki Neurosurgical Hospital, Hiroshima, Hiroshima, Japan
5Department of Neurosurgery, Chugoku Rosai Hospital, Kure, Hiroshima, Japan
6Department of Neurosurgery, Shimane University Faculty of Medicine, Izumo, Shimane, Japan
7Department of Clinical Epidemiology, School of Public Health, Graduate School of Medicine, Kyoto University, Kyoto, Kyoto, Japan
8Department of Health Informatics, School of Public Health, Graduate School of Medicine, Kyoto University, Kyoto, Kyoto, Japan
9Department of Neurosurgery, Kochi Medical School, Kochi University, Kochi, Kochi, Japan
10Department of Surgical Neurology, Akita Cerebrospinal and Cardiovascular Center, Akita, Akita, Japan
11Department of Neurosurgery, Hirosaki University Graduate School, Hirosaki, Aomori, Japan

Abstract

The “Izumo Study” revealed the incidence rate of subarachnoid hemorrhage (SAH) in Izumo City, Shimane Prefecture, Japan, from 1980 to 1998. However, no study has been published regarding the incidence of SAH in Shimane Prefecture after 1998. Most studies reporting the incidence of SAH in Japan have been conducted before 2000, although a few have been reported after 2000. This study aimed to assess the estimated age-adjusted incidence rate (AAIR) of SAH in Shimane Prefecture after 1998, following the Izumo Study. A retrospective study was conducted to identify the estimated AAIR of SAH in Shimane Prefecture, using the age-adjusted SAH mortality rate for this population from 1999 to 2017 and assuming that the case-fatality rate of SAH decreased by 0.7% annually from 45% in 1999 to 32.4% in 2017. We used linear regression analysis for trend to the estimated AAIR of SAH. Sensitivity analyses were also conducted by various case-fatality rates of SAH using assuming case-fatality rate based on previous reports. The estimated AAIR of SAH in Shimane Prefecture declined from 33.6 (95% confidence interval [CI]: 29.7-37.9) per 100,000 person-years in 1999, by 26.5%, to 24.7 (95% CI: 21.4-28.5) in 2017 (p < 0.01, r = 0.58). Declining trend of incidence rate of SAH in Shimane Prefecture from 1999 to 2017 was confirmed in this study.

Keywords: subarachnoid hemorrhage, register-based study, aging population, incidence
**Introduction**

The crude global incidence rate of subarachnoid hemorrhage (SAH) was previously reported to be 9 per 100,000 person-years, although it varied widely according to geographic location, age, sex, race, and period.\(^1,10\) A recent meta-analysis revealed that the global incidence of SAH declined by 40% between 1980 and 2010.\(^8\) However, in Japan alone, in contrast to global trends, the incidence of SAH has increased by 59.1% over the last three decades.\(^9\) Almost all previous studies for the incidence of SAH in Japan were conducted with data only up to 2008.\(^3,10\) Moreover, Ikawa and colleagues recently published a register-based study and reported that the estimated age-standardized nationwide SAH incidence rate in Japan was higher than those in other countries. However, it had declined from 31.3 (95% confidence interval [CI]: 31.3-31.3) per 100,000 person-years in 2003 to 27.6 (95% CI: 27.6-27.6) in 2015.\(^7\) Inagawa et al.'s "Izumo Study" assessed the incidence rate of SAH in Izumo City, Shimane Prefecture, Japan, prior to 1998. The age-adjusted incidence rate (AAIR) of SAH in Izumo City was as high as 23 (95% CI: 20-27) per 100,000 person-years between 1980 and 1989, and thereafter it was stable, 23 (95% CI: 20-26) between 1990 and 1998.\(^8,11\) This area is one of the main regions of Shimane Prefecture, known to be favorable to epidemiological surveillance owing to the existence of few large industries and relatively stable social and demographic compositions of the population. There have been few reports on the most recent incidence rate of SAH in Japan.\(^12,13\) Furthermore, any recent changes in the incidence rate of SAH in the local region of Izumo City, Shimane Prefecture, have not been assessed following the Izumo Study.

Following the previous studies in Shimane Prefecture,\(^3,8,11,14\) this study aimed to assess the estimated AAIR of SAH trends according to the age-adjusted mortality rate (AAMR) of SAH in the two decades following the Izumo Study.

**Materials and Methods**

**Ethical statement**

This study was approved as the Japan Incidence of SAH (JIS) study by the Institutional Review Board (No. R19-056; Clinical registration URL: http://www.umin.ac.jp/icdr/inde x.html; title: Japan Incidence of SAH [JIS] study; ID: UMIN 000039962; No. R000045530). Owing to the anonymous nature of the data, the requirement for informed consent by patients was waived, and an opt-out method was used as a proxy for informed consent in this study. The JIS study comprised four regions, namely, Aomori, Akita, Shimane, and Kochi Prefectures, and this study in Shimane Prefecture is the first region of the JIS study.

**Patient population and data source**

Shimane Prefecture is located in the western part of mainland Japan and covers a rural area of 6,708 km\(^2\); further, this prefecture is favorable for epidemiological studies because of its relatively stable population composition.\(^9\) A retrospective study of data from the Shimane Prefecture population was performed. This included examining the number of deaths\(^9\) caused by SAH and changes in the Shimane Prefecture population\(^9\) using the government statistics database between 1999 and 2017. The standard population of Shimane Prefecture and Japan in 2000 was adjusted for age.\(^10\)

**Accuracy of register-based diagnosis of SAH and mortality**

According to the law of Japan, all causes of death are reported to the government office and calculated in each prefecture. In Japan, computed tomography (CT) scans were pervasive, even in rural areas, and emergent or autopsy CT scans were conducted for almost all sudden deaths. Thus, the number of deaths caused by SAH based on governmental data could be considered almost accurate.

**Calculation of AAMR and AAIR of SAH**

The AAMR was calculated using the number of deaths caused by SAH every 5 years in Shimane Prefecture and the population data of 5-year age groups from the Shimane Prefecture population in 2000 as standard.\(^9\) Additionally, the AAMR of SAH in Shimane Prefecture was calculated using data of the entire Japanese population in 2000 as standard to allow comparisons with the Izumo Study results.

The case-fatality rate of SAH was reported to range from 32% to 45%\(^17,18\) and the Izumo Study reported that the case-fatality rate of SAH in Izumo City was 39% between 1980 and 1989 and 36% between 1990 and 1998.\(^10\) Therefore, in consideration of previous reports, assuming that the case-fatality rate decreased by 0.7% annually (from 45% in 1999 to 32.4% in 2017), we estimated the AAIR of SAH from the AAMR of SAH. The formula for the estimated AAIR of SAH is: (AAMR of SAH) / (case-fatality rate of SAH). Additionally, to evaluate the accuracy of the estimated AAIR of SAH in Shimane Prefecture, we conducted sensitivity analyses by changing both the case-fatality rate of SAH and annual change in the case-fatality rate of SAH, based on a range of assumed mortality and annual change rate. We used assumed case-fatality rate of SAH in 1999 from 25% to 45% at 5% intervals and annual changes in the case-fatality rate of SAH from −1% to 1% at 0.5% intervals. As a result of sensitivity analysis, it was divided into 25 patterns.

**Statistical analysis**

For each year, the AAMR of SAH in Shimane Prefecture,
with the corresponding 95% CI, was calculated using Poisson methods.\textsuperscript{19} We used linear regression analysis for trend to the estimated AAIR of SAH. All p-values were two sided, and p-values of <0.05 were considered statistically significant. All statistical analyses were performed with EasyR, a modified version of R commander (version 1.6-3) that was designed to add statistical functions\textsuperscript{20} to R (The R Foundation for Statistical Computing, Vienna, Austria, version 2.13.0).

**Results**

**Analyses of the entire cohort**

The population in Shimane Prefecture declined by 10.4%, from 764,291 in 1999 to 684,668 in 2017. In addition to this depopulation trend, Shimane Prefecture rapidly became an aging society, wherein 24.3% and 33.2% of the population were aged 65 years or older in 1999 and 2017, respectively. Both the number of deaths by SAH and crude mortality rate of SAH in Shimane Prefecture declined from 1999 to 2017 (Table 1).

**AAMR and AAIR of SAH using the Shimane Prefecture population in 2010 as standard**

Using the Shimane Prefecture population in 2000 as standard, the AAMR of SAH declined by 47.0%, regardless of sex, from 15.1 (95% CI: 12.6-18.1) per 100,000 person-years in 1999 to 8.0 (95% CI: 6.2-10.3) in 2017. Similarly, the estimated AAIR of SAH in Shimane Prefecture declined by 26.5% from 1999 to 2017, regardless of sex. It ranged from 33.6 (95% CI: 29.7-37.9) per 100,000 person-years in 1999 to 24.7 (95% CI: 21.4-28.5) in 2017 (p < 0.01, r = 0.58), after using the assumed annual change in case-fatality rate of SAH (Fig. 1 and Table 2).

**AAMR and AAIR of SAH using the entire population of Japan in 2000 as standard**

Using the entire population of Japan in 2000 as standard, the AAMR of SAH in Shimane Prefecture declined by 44.4% between 1999 and 2017, regardless of sex, from 11.7 (95% CI: 11.5-11.9) per 100,000 person-years in 1999 to 6.5 (95% CI: 6.4-6.6) in 2017. Similarly, the estimated AAIR of SAH in Shimane Prefecture declined by 22.7% from 26.0 (95% CI: 25.7-26.3) per 100,000 person-years in 1999 to 20.1 (95% CI: 19.8-20.3) in 2017 (Table 3).

**Sensitivity analysis**

Sensitivity analyses for the estimated AAIR of SAH in Shimane Prefecture using the Shimane Prefecture population in 2000 as standard showed that 92.0% of all values declined from 1999 to 2017, except for 3 patterns, and that 60.0% of all values bottomed in 2017, except for 10 pat-
Subarachnoid Hemorrhage Incidence in Japan

Fig. 1 Estimated age-adjusted incidence rate of subarachnoid hemorrhage in Shimane Prefecture regardless of sex from 1999 to 2017.

Table 2 Assuming case-fatality rate, age-adjusted mortality rate, and estimated age-adjusted incidence rate of subarachnoid hemorrhage in Shimane Prefecture per 100,000 person-years from 1999 to 2017 using the Shimane Prefecture population in 2000 as standard

| Year | Case-fatality rate | Age-adjusted mortality rate | Estimated age-adjusted incidence rate |
|------|--------------------|----------------------------|--------------------------------------|
|      |                    | All Male Female            | All Male Female                       |
| 1999 | 45.0               | 15.1 (12.6–18.1) 9.4 (6.7–13.1) | 20.3 (16.4–25.3) 33.6 (29.7–37.9) |
| 2000 | 44.3               | 15.2 (12.7–18.2) 11.8 (8.8–15.9) | 18.3 (14.6–23.0) 34.3 (30.4–38.7) |
| 2001 | 43.6               | 16.2 (13.6–19.3) 10.8 (7.9–14.8) | 21.1 (17.0–26.1) 37.2 (33.1–41.7) |
| 2002 | 42.9               | 14.2 (11.7–17.1) 9.5 (6.8–13.2) | 18.4 (14.6–23.1) 33.1 (29.3–37.4) |
| 2003 | 42.2               | 12.1 (9.9–14.9) 9.0 (6.4–12.7) | 15.0 (11.6–19.3) 28.7 (25.1–32.7) |
| 2004 | 41.5               | 12.5 (10.2–15.3) 8.2 (5.8–11.7) | 16.4 (12.8–20.8) 30.1 (26.5–34.3) |
| 2005 | 40.8               | 12.0 (9.7–14.7) 6.9 (4.7–10.2) | 16.7 (13.2–21.3) 29.4 (25.8–33.5) |
| 2006 | 40.1               | 11.2 (9.0–13.8) 7.6 (5.3–11.1) | 14.5 (11.2–18.7) 27.9 (24.4–31.9) |
| 2007 | 39.4               | 11.8 (9.6–14.5) 6.9 (4.7–10.2) | 16.2 (12.7–20.6) 29.9 (26.3–34.1) |
| 2008 | 38.7               | 9.5 (7.6–12.0) 7.5 (5.1–10.9) | 11.2 (8.4–15.0) 24.5 (21.3–28.3) |
| 2009 | 38.0               | 10.6 (8.6–13.2) 10.6 (7.8–14.5) | 10.7 (7.9–14.4) 27.9 (24.4–31.9) |
| 2010 | 37.3               | 9.6 (7.6–12.1) 6.6 (4.5–9.8) | 12.4 (9.4–16.4) 25.7 (22.4–29.6) |
| 2011 | 36.6               | 11.7 (9.5–14.4) 8.4 (5.9–11.9) | 15.0 (11.6–19.3) 32.0 (28.2–36.2) |
| 2012 | 35.9               | 9.1 (7.2–11.5) 7.6 (5.2–11.0) | 10.5 (7.8–14.2) 25.3 (22.0–29.2) |
| 2013 | 35.2               | 9.2 (7.3–11.7) 8.1 (5.7–11.6) | 10.3 (7.6–14.0) 26.1 (22.8–30.0) |
| 2014 | 34.5               | 10.2 (8.1–12.7) 7.3 (5.0–10.6) | 13.1 (10.0–17.1) 29.6 (26.0–33.7) |
| 2015 | 33.8               | 8.2 (6.4–10.4) 8.8 (6.2–12.4) | 7.4 (5.2–10.6) 24.3 (21.0–28.0) |
| 2016 | 33.1               | 8.3 (6.5–10.6) 4.6 (2.9–7.4) | 11.7 (8.8–15.5) 25.1 (21.8–28.9) |
| 2017 | 32.4               | 8.0 (6.2–10.3) 5.5 (3.6–8.5) | 10.4 (7.7–14.1) 24.7 (21.4–28.5) |

terms. In addition to 2017, bottom years were 2015 for five patterns, 2008 for four, and 1999 for one. The change rate of the estimated AAIR of SAH in Shimane Prefecture from 1999 to 2017 ranged from −69.2% to 90.2%, with a mean of −34.9% (standard deviation: 36.7%) (Table 4).

Neurol Med Chir (Tokyo) 62, October, 2022
Table 3 Assuming case-fatality rate, SAH mortality rate, and estimated age-adjusted incidence rate of SAH per 100,000 person-years from 1999 to 2017, using the entire population of Japan in 2000 as standard

| Year | Case-fatality rate | Age-adjusted mortality rate | Estimated age-adjusted incidence rate |
|------|------------------|----------------------------|--------------------------------------|
|      | All | Male | Female | All | Male | Female |
| 1999 | 45.0 | 11.7 (11.5–11.9) | 7.9 (7.7–8.1) | 15.2 (14.9–15.5) | 26.0 (25.7–26.3) | 17.6 (17.2–17.9) | 33.6 (33.3–34.2) |
| 2000 | 44.3 | 11.5 (11.3–11.7) | 9.6 (9.4–9.8) | 13.1 (12.8–13.4) | 26.0 (25.7–26.2) | 21.7 (21.3–22.0) | 34.3 (29.2–30.0) |
| 2001 | 43.6 | 11.8 (11.6–12.0) | 8.4 (8.2–8.6) | 15.1 (14.8–15.4) | 27.1 (26.8–27.4) | 19.3 (18.9–19.6) | 37.2 (34.2–35.1) |
| 2002 | 42.9 | 10.8 (10.6–11.0) | 7.9 (7.7–8.1) | 13.6 (13.3–13.9) | 25.2 (24.9–25.5) | 18.4 (18.1–18.8) | 33.1 (31.3–32.1) |
| 2003 | 42.2 | 9.5 (9.3–9.7) | 7.7 (7.5–7.9) | 11.1 (10.8–11.4) | 22.5 (22.3–22.8) | 18.2 (17.9–18.6) | 28.7 (25.9–26.7) |
| 2004 | 41.5 | 9.3 (9.1–9.5) | 6.7 (6.5–6.9) | 11.6 (11.3–11.9) | 22.4 (22.2–22.7) | 16.1 (15.8–16.5) | 30.1 (27.5–28.4) |
| 2005 | 40.8 | 9.1 (8.9–9.3) | 5.6 (5.4–5.8) | 12.4 (12.1–12.7) | 22.3 (22.0–22.6) | 13.7 (13.4–14.0) | 29.4 (30.0–30.8) |
| 2006 | 40.1 | 8.3 (8.1–8.5) | 6.4 (6.2–6.6) | 10.1 (9.9–10.3) | 20.7 (20.4–21.0) | 16.0 (15.6–16.3) | 27.9 (24.8–25.6) |
| 2007 | 39.4 | 8.9 (8.7–9.1) | 5.8 (5.6–6.0) | 11.8 (11.5–12.1) | 22.6 (22.3–22.9) | 14.7 (14.4–15.0) | 29.9 (29.5–30.4) |
| 2008 | 38.7 | 7.0 (6.9–7.1) | 6.2 (6.0–6.4) | 7.7 (7.5–7.9) | 18.1 (17.9–18.3) | 16.0 (15.7–16.3) | 24.5 (19.6–20.2) |
| 2009 | 38.0 | 8.4 (8.2–8.6) | 9.2 (9.0–9.4) | 7.6 (7.4–7.8) | 22.1 (21.8–22.4) | 24.2 (23.8–24.6) | 27.9 (19.7–20.3) |
| 2010 | 37.3 | 7.6 (7.4–7.8) | 6.0 (5.8–6.2) | 9.2 (9.0–9.4) | 20.4 (20.1–20.6) | 15.8 (15.6–16.4) | 25.7 (24.3–25.1) |
| 2011 | 36.6 | 8.9 (8.7–9.1) | 7.2 (7.0–7.4) | 10.6 (10.4–10.9) | 24.3 (24.0–24.6) | 19.7 (19.3–20.0) | 32.0 (28.6–29.4) |
| 2012 | 35.9 | 7.3 (7.2–7.5) | 6.5 (6.5–6.9) | 7.9 (7.7–8.1) | 20.3 (20.1–20.6) | 18.3 (18.3–19.0) | 25.3 (21.6–22.4) |
| 2013 | 35.2 | 7.4 (7.3–7.6) | 7.0 (6.8–7.2) | 7.7 (7.5–7.9) | 21.0 (20.8–21.3) | 19.9 (19.5–20.2) | 26.1 (21.5–22.2) |
| 2014 | 34.5 | 8.0 (7.8–8.2) | 6.4 (6.2–6.6) | 9.8 (9.6–10.0) | 23.2 (22.9–23.5) | 18.6 (18.2–18.9) | 29.6 (28.0–28.8) |
| 2015 | 33.8 | 6.6 (6.5–6.7) | 7.6 (7.4–7.8) | 5.6 (5.4–5.8) | 19.5 (19.3–19.8) | 22.5 (22.1–22.9) | 24.3 (16.3–16.9) |
| 2016 | 33.1 | 6.4 (6.3–6.5) | 3.8 (3.6–4.0) | 8.9 (8.7–9.1) | 19.3 (19.1–19.6) | 11.5 (11.2–11.8) | 25.1 (26.5–27.3) |
| 2017 | 32.4 | 6.5 (6.4–6.6) | 5.0 (4.8–5.2) | 8.0 (7.8–8.2) | 20.1 (19.8–20.3) | 15.4 (15.1–15.7) | 24.7 (24.3–25.1) |

SAH: subarachnoid hemorrhage

Discussion

Recent declining trend of AAIR after the Izumo Study

This register-based study revealed that novel results regarding the estimated AAIR of SAH in Shimane Prefecture declined by 26.5% from 33.6 (95% CI: 29.7–37.9) per 100,000 person-years in 1999 to 24.7 (95% CI: 21.4–28.5) in 2017. Therefore, the estimated AAIR of SAH in Shimane Prefecture, when combining results from the Izumo Study, tended to be stable as 23 per 100,000 person-years from 1980 to 1988 and afterwards showed a declining trend from 1999 to 2017. The recent declining trend of the estimated AAIR of SAH in Shimane Prefecture could be confirmed at least between 1999 and 2017, and the trends of incidence of SAH in other areas of Japan would be researched in the JIS study in the next step.

The estimated AAIR of SAH in Shimane Prefecture in this study was substantially higher than those in previous studies. This higher incidence rate may be attributed to the older age of the Shimane Prefecture population. The estimated AAIR of SAH was determined by the incidence rate of SAH in each 5-year age group; if the incidence rate of SAH in each 5-year age group changed drastically from that of the standard year, the estimated AAIR of SAH would change accordingly. Treatment, transport, and imaging methods of SAH were not expected to change drastically during the study period; however, the aging population accelerated in Shimane Prefecture and Japan overall. This rapidly aging population could be the reason for the remarkably higher estimated AAIR of SAH. Furthermore, because of selecting the Japanese population in 2000 as standard instead of the Shimane Prefecture population, the estimated AAIR of SAH in Shimane Prefecture during the study period could be lower value and close value to the Izumo Study standardized by the Japanese population in 1995 (Table 3). The Shimane Prefecture population was the second most aging population in Japan; therefore, the estimated AAIR of SAH in Shimane Prefecture was accordingly extremely high.

The case-fatality rate of SAH improved during the study period, although it was higher in the elderly population. The accurate case-fatality rate in Shimane Prefecture could be calculated only by the community-based study, such as the Izumo Study, and accurate case-fatality rate was not available in the present study, which might also change each year. Therefore, the case-fatality rate in the present study was assumed in consideration of previous reports, and we conducted sensitivity analyses by changing the case-fatality rate of SAH and annual change rates to overcome this limitation. Hence, 92.0% of all values declined from 1999 to 2017, and 60.0% of all values bottomed in 2017 and 20.0% in 2015 (Table 4). Therefore,
Conclusions

The estimated AAIR of SAH in Shimane Prefecture showed a declining trend from 1999 to 2017. Further studies are warranted to evaluate the recent trend of the incidence rate of SAH at other areas in Japan.

Acknowledgments

We wish to thank all the participants whose data we used.

Conflicts of Interest Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.
References

1) de Rooij NK, Linn FH, van der Plas JA, Algra A, Rinkel GJ: Incidence of subarachnoid hemorrhage: a systematic review with emphasis on region, age, gender and time trends. *J Neurol Neurosurg Psychiatry* 78: 1365-1372, 2007

2) Etminan N, Chang HS, Hackenberg K, et al.: Worldwide incidence of aneurysmal subarachnoid hemorrhage according to region, time period, blood pressure, and smoking prevalence in the population: a systematic review and meta-analysis. *JAMA Neurol* 76: 588-597, 2019

3) Korja M, Lehto H, Juvela S, Kaprio J: Incidence of subarachnoid hemorrhage is decreasing together with decreasing smoking rates. *Neurology* 87: 1118-1123, 2016

4) van Gijn J, Kerr RS, Rinkel GJE: Subarachnoid hemorrhage. *Lancet* 369: 306-318, 2007

5) Omama S, Yoshida Y, Ogasawara K, et al.: Incidence rate of cerebrovascular diseases in northern Japan determined from the Iwate Stroke Registry with an inventory survey system. *J Stroke Cerebrovasc Dis* 22: e317-e322, 2013

6) Tanaka H, Ueda Y, Date C, et al.: Incidence of stroke in Shibata, Japan: 1976-1978. *Stroke* 12: 460-466, 1981

7) Ikawa F, Morita A, Nakayama T, et al.: A register-based SAH study in Japan: high incidence rate and recent decline trend based on lifestyle. *J Neurosurg* 134: 983-991, 2020

8) Inagawa T, Ishikawa S, Aoki H, Takahashi M, Yoshimoto H: Aneurysmal subarachnoid hemorrhage in Izumo City and Shimane Prefecture of Japan. Incidence. *Stroke* 19: 170-175, 1988

9) Inagawa T, Tokuda Y, Ohbayashi N, Takaya M, Moritake K: Study of aneurysmal subarachnoid hemorrhage in Izumo City, Japan. *Stroke* 26: 761-766, 1995

10) Inagawa T: Trends in incidence and case fatality rates of aneurysmal subarachnoid hemorrhage in Izumo City, Japan, between 1980-1989 and 1990-1998. *Stroke* 32: 1499-1507, 2001

11) Inagawa T, Takechi A, Yahara K, et al.: Primary intracerebral and aneurysmal subarachnoid hemorrhage in Izumo City, Japan. Part I: Incidence and seasonal and diurnal variations. *J Neurosurg* 93: 958-966, 2000

12) Takashima N, Arima H, Kita Y, et al.: Incidence, management and short-term outcome of stroke in a general population of 1.4 million Japanese — Shiga Stroke Registry. *Circ J* 81: 1636-1646, 2017

13) Nomura S, Kunitsugu I, Ishihara H, et al.: Relationship between aging and enlargement of intracranial aneurysms. *J Stroke Cerebrovasc Dis* 24: 2049-2053, 2015

14) Ikawa F, Hidaka T, Yoshiyama M, et al.: Characteristics of cerebral aneurysms in Japan. *Neurol Med Chir (Tokyo)* 59: 399-406, 2019

15) Statistics of Japan Ministry of Health Labor and Welfare: Portal Site of Official Statistics of Japan. https://www.e-stat.go.jp/en/stat-search/files?page=1&kikan=00450 (Accessed Dec 22 2020)

16) Statistics Bureau of Japan. Ministry of Internal Affairs and Communications, Japan: Population Census 2010. http://www.stat.go.jp/english/data/kokusei/index.html (Accessed Dec 22 2020)

17) Koffijberg H, Buskens E, Granath F, et al.: Subarachnoid hemorrhage in Sweden 1987-2002: regional incidence and case fatality rates. *J Neurol Neurosurg Psychiatry* 79: 294-299, 2008

18) Sandvei MS, Mathiesen EB, Vatten LJ, et al.: Incidence and mortality of aneurysmal subarachnoid hemorrhage in two Norwegian cohorts, 1984-2007. *Neurology* 77: 1833-1839, 2011

19) Poisson PSD: Recherches sur la probabilité des Judgments. Bachelor, Imprimeur-Libraire, 1857

20) Kanda Y: Investigation of the freely available easy-to-use software ‘EZRB’ for medical statistics. *Bone Marrow Transplantation* 48: 452-458, 2013

21) Alleyne CH Jr: Aneurysmal subarachnoid hemorrhage: have outcomes really improved? *Neurology* 74: 1486-1487, 2010

22) The-ACROSS-Group: Epidemiology of aneurysmal subarachnoid hemorrhage in Australia and New Zealand: incidence and case fatality from the Australasian Cooperative Research on Subarachnoid Hemorrhage Study (ACROSS). *Stroke* 31: 1843-1850, 2000

23) Hop JW, Rinkel GJ, Algra A, van Gijn J: Case-fatality rates and functional outcome after subarachnoid hemorrhage: a systematic review. *Stroke* 28: 660-664, 1997

Corresponding author: Fusao Ikawa, M.D., Ph.D.
Department of Neurosurgery, Shimane Prefectural Central Hospital, 4-1-1 Himebara, Izumo, Shimane 693-8555, Japan.
e-mail: fikawa-nsu@umin.ac.jp