PROJECTION OF MORTALITY FROM CEREBROVASCULAR DISEASE, 1985 THROUGH 2000 A.D., IN JAPAN

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Trends of mortality from cerebrovascular disease from 1985 to 2000 were projected by a semi-logarithmic linear regression analysis based on the deaths and population by sex and age from 1973 to 1982. Crude death rates from cerebrovascular disease and cerebral hemorrhage in particular will continue to decrease but the change in death rate from cerebral infarction will remain relatively small. In the period from 1985 to 2000, the death rate from cerebral hemorrhage will decline sharply, and the death rate from cerebral infarction also is expected to decline steadily in every age group. These declines will lead to the decrease in age-adjusted death rates from these cerebrovascular diseases. The average change in the number of the deaths from 1982 to 2000 is minus 3.7% per year for cerebral hemorrhage and plus 0.8% per year for cerebral infarction. The slight increase in deaths from cerebral infarction will be due primarily to an increase in the over 80 year old population. As a result, the proportion of the deaths from cerebral infarction among all types of cerebrovascular diseases will continue to increase in Japan. These future declining trends hopefully can be further modified by improvement in dietary habits and better treatment of high risk groups.

The proportion of people aged over 65 years in the Japanese population increased three percent a year over the past ten years, and the top leading cause of death in the 75 to 89 year age group in 1982 was cerebrovascular disease. Although the age-adjusted death rate from cerebrovascular disease in Japan has been decreasing since 1965, it is still at a relatively high level, compared with those in the other developed countries.

In many countries, recent changes in the structure of diseases have been accompanied by changes in dietary habits, progress in public health and medical care or an increase in the aged population. It is, therefore, worth noting to what degree the risk factors and estimated death figures from cerebrovascular diseases can be managed by more efficient preventive activities in Japan.

In order to improve the preventive activities against cerebrovascular disease, one of the most prevalent ailments in Japan, it is essential to forecast future mortality trends of the disease from current data.

This paper supplies the basic data necessary for setting a practical goal of modifying projected mortality figures by reducing the incidence of cerebrovascular diseases through the control of risk factors.

MATERIALS AND METHODS
Age-specific death rates from cerebrovascular

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Key Words:
Cerebrovascular disease
Projection of mortality
Regression analysis
Epidemiology

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disease in Japan from 1985 to 2000 were predicted by semi-logarithmic linear regression analysis based on the deaths and population by sex and age from 1973 to 1982. The regression equation was obtained from the following formula: \( \log(Y) = a(x) + \text{constant} \), where \( X \) is year, \( Y \) is the corresponding age-specific death rate, “a” is the regression coefficient, and “log” means common logarithm. The age-groupings were 0–29, 30–39, 40–49, 50–59, 60–69, 70–79 and 80 years and over.

The number of deaths in the coming years were computed by summing up each predicted age group-specific death rate multiplied by the corresponding estimated population. Crude death rates from cerebrovascular diseases in Japan from 1985 through 2000 were obtained by dividing the total number of the deaths mentioned above by the predicted future population in Japan. The age-adjusted death rates in the same period were estimated by a direct standardization method with the modified Segi-Doll’s “world population” as the standard population.

The code numbers of the International Classification of Diseases (ICD 8 or 9) in this study were 430–438 for cerebrovascular disease, 431 and 432 for cerebral hemorrhage, and 433 and 434 for cerebral infarction.

The computer used for the calculation of regression equations and future death rates for cerebrovascular diseases in Japan was a NEC ACOS-1000 system at the Osaka University Computer Center.

RESULTS

1) Future trend of age-specific death rate from cerebrovascular disease

In every age group, death rates from cerebrovascular disease in males and in females from 1973 to 2000 are predicted to decrease, and in 2000 the death rate in each age group corresponds to the 1975 rate of the ten-years-younger age group. (Fig. 1)

The death rate from cerebral hemorrhage will decline sharply for every age group. In 2000 the death rate of each age group is expected to equal that of the 1985 ten-years-younger age group and the 1975 twenty-years-younger age group. (Fig. 2)

In every age group, the death rate from cerebral
infarction will continue to decline, but not as rapidly as that for cerebral hemorrhage. (Fig. 3)

II) Future trend of crude death rate from cerebrovascular disease

The crude death rate in males from cerebrovascular disease as a whole is estimated to be 100.3 per 100,000 in 1990 and 70.5 in 2000, decreasing 3.0% per year, and in females it is estimated to be 107.6 in 1990 and 83.5 in 2000, decreasing 2.2% per year. The steepest reduction is expected in the death rates from cerebral hemorrhage, i.e., a death rate in males of 24.5 in 1990 and 12.4 in 2000, minus 4.9% per year, and in females 21.2 in 1990 and 10.9 in 2000, minus 4.9% per year. The future annual change in crude death rates from cerebral infarction will be relatively small, minus 0.5% in males, and plus 0.1% in females. (Table I)

III) Future trend of age-adjusted death rate from cerebrovascular disease

The age-adjusted death rate in males from cerebrovascular disease as a whole is expected to be 68.4 per 100,000 in 1990 and 37.9 in 2000, decreasing 4.5% per year, and in females it is estimated to be 48.6 in 1990 and 28.0 in 2000, decreasing 4.2% per year. A steeper reduction is expected for cerebral hemorrhage, i.e., the age-adjusted death rate in males is 17.5 in 1990 and 7.6 in 2000, minus 5.7% per year, and in females it is 10.9 in 1990 and 4.6 in 2000, minus 5.8% per year. The change in age-adjusted death rates from cerebral infarction in this period is estimated at minus 2.7% per year for both sexes. (Table II)

IV) Trend of number of deaths from cerebrovascular disease

The total number of deaths from all types of cerebrovascular disease is predicted to decrease steadily, from 147,500 in 1982 (males and females combined) to 127,800 in 1990 and 98,900 in 2000. The trend for cerebral hemorrhage contrasts with that for cerebral infarction, i.e., the number of deaths from cerebral hemorrhage is 44,100 in 1982, 28,000 in 1990, and 14,800 in 2000, minus 3.7% per year for this 18-year period, and the number of deaths from

![Graph showing age-specific death rates from cerebral infarction.](image)

**TABLE I CRUDE DEATH RATES FROM CEREBROVASCULAR DISEASES IN JAPAN, 1973~2000 A.D.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Males</th>
<th>CVD</th>
<th>C. Hemo.</th>
<th>C. Inf.</th>
<th>Females</th>
<th>CVD</th>
<th>C. Hemo.</th>
<th>C. Inf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>177.9</td>
<td>75.0</td>
<td>63.5</td>
<td></td>
<td>156.1</td>
<td>60.6</td>
<td></td>
<td>60.1</td>
</tr>
<tr>
<td>1982</td>
<td>126.0</td>
<td>40.5</td>
<td>59.6</td>
<td></td>
<td>124.0</td>
<td>34.3</td>
<td></td>
<td>60.1</td>
</tr>
<tr>
<td>1985</td>
<td>118.1</td>
<td>33.5</td>
<td>62.3</td>
<td></td>
<td>119.8</td>
<td>28.8</td>
<td></td>
<td>65.0</td>
</tr>
<tr>
<td>1990</td>
<td>100.3</td>
<td>24.5</td>
<td>61.4</td>
<td></td>
<td>107.6</td>
<td>21.2</td>
<td></td>
<td>66.7</td>
</tr>
<tr>
<td>1995</td>
<td>84.7</td>
<td>17.6</td>
<td>60.4</td>
<td></td>
<td>96.4</td>
<td>15.4</td>
<td></td>
<td>68.2</td>
</tr>
<tr>
<td>2000</td>
<td>70.5</td>
<td>12.4</td>
<td>58.6</td>
<td></td>
<td>83.5</td>
<td>10.9</td>
<td></td>
<td>67.1</td>
</tr>
</tbody>
</table>

*CVD = Cerebrovascular disease; C. Hemo. = Cerebral Hemorrhage; C. Inf. = Cerebral Infarction.*

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TABLE II AGE-ADJUSTED DEATH RATES FROM CEREBROVASCULAR DISEASES IN JAPAN, 1973–2000 A.D.

<table>
<thead>
<tr>
<th>Year</th>
<th>Males</th>
<th></th>
<th></th>
<th>Females</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CVD</td>
<td>C. Hemo.</td>
<td>C. Inf.</td>
<td>CVD</td>
<td>C. Hemo.</td>
<td>C. Inf.</td>
</tr>
<tr>
<td>1973</td>
<td>191.9</td>
<td>79.5</td>
<td>70.0</td>
<td>128.1</td>
<td>50.7</td>
<td>48.1</td>
</tr>
<tr>
<td>1982</td>
<td>107.2</td>
<td>34.8</td>
<td>50.3</td>
<td>74.3</td>
<td>22.0</td>
<td>34.0</td>
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<td>1985</td>
<td>92.5</td>
<td>26.9</td>
<td>48.1</td>
<td>64.6</td>
<td>17.0</td>
<td>32.8</td>
</tr>
<tr>
<td>1990</td>
<td>68.4</td>
<td>17.5</td>
<td>41.0</td>
<td>48.6</td>
<td>10.9</td>
<td>27.8</td>
</tr>
<tr>
<td>1995</td>
<td>50.8</td>
<td>11.5</td>
<td>33.0</td>
<td>36.8</td>
<td>7.1</td>
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<td>2000</td>
<td>37.9</td>
<td>7.6</td>
<td>29.9</td>
<td>28.0</td>
<td>4.6</td>
<td>20.3</td>
</tr>
</tbody>
</table>

CVD = Cerebrovascular disease; C. Hemo. = Cerebral Hemorrhage; C. Inf. = Cerebral Infarction.

TABLE III STANDARDIZED COEFFICIENTS OF MULTIPLE LOGISTIC FUNCTION FOR 10-YEAR AGE-ADJUSTED MORTALITY FROM CEREBROVASCULAR DISEASE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standardized coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>0.888**</td>
</tr>
<tr>
<td>Animal protein</td>
<td>-0.093 ns</td>
</tr>
<tr>
<td>Fats</td>
<td>-0.114 ns</td>
</tr>
<tr>
<td>Animal fats</td>
<td>-0.051 ns</td>
</tr>
</tbody>
</table>

**p < 0.01  ns = not significant  (Based on National Nutrition Survey)

cerebral infarction is 70,600 in 1982, 78,700 in 1990, and 80,500 in 2000, plus 0.8% per year for the same period. The increase in deaths from cerebral infarction is due to an increase in the highest age group, 80 years and over, in the population.

As the result, the proportion of the deaths in Japan from cerebral infarction among all types of cerebrovascular diseases will increase plus 3.9% per year from 1982 to 2000.

DISCUSSION

As seen in Figs. 1, 2 and 3, the death rate for each age group changes almost linearly on the semi-logarithmic scales from 1973 through 1982, and the future death rate from cerebrovascular disease can best be estimated by means of semi-logarithmic linear regression analysis; the chi-square test showed that no significant difference existed between the observed death rates and the ones estimated by semi-logarithmic regression equations from 1973 to 1982 for any of the age groups. In this study projected mortalities from cerebrovascular diseases in the future population by age-groups have been considered. Future predicted mortality from cerebrovascular disease should be modified by more efficient public health activities, progress in medical care and more rapid and positive changes in life style. These factors can be evaluated quantitatively by simulation analyses of effects of antihypertensive efforts, improved dietary habits, etc. on the incidence of cerebrovascular disease. The proportion of aged people has been increasing, i.e., 7.5% of the total population in 1973, 9.6% in 1982, and an estimated 15.6% in 2000. Any projection of the death rates could not be performed appropriately without consideration of the evolving age distribution in Japan.

Mortality data in this study were based on the eighth (1978) and ninth (1979–) revisions of the International Classification of Diseases. But the correction coefficient for cerebrovascular disease was nearly one, as demonstrated by the Statistics and Information Department, Ministry of Health and Welfare 7; no correction of the mortality data was made for comparative purposes.

By comparing the diagnostic accuracy of cerebrovascular diseases by type before and after...
computerized axial tomography, Ichikawa et al. suggested that cerebrovascular diseases were usually correctly diagnosed by general physicians; the accuracy in diagnosis of cerebral hemorrhage or cerebral infarction was 70% and 83%, respectively. The reliability of medical diagnosis in general is expected to improve in the future.

This study shows that the age-specific death rates from both cerebral hemorrhage and cerebral infarction will decline in every age group, with the decline more marked for cerebral hemorrhage.

In 1982 the crude death rate from cerebrovascular disease as a whole was 126 per 100,000 in males and 124 in females, and the rate in 2000 will be 70.5 in males and 83.5 in females, with a female to male sex ratio of 1.2. In the future, age-adjusted death rates from all types of cerebrovascular disease also are expected to decrease.

The future death rate from cerebrovascular disease will be strongly affected by progress in medical care and changes in health behavior and dietary habits. According to the National Nutrition Survey, in 1960–1979 increases in intake were observed for animal protein (+3.8% per year), animal fats and oils (+14.3%), meats (+12.7%), and milk (+13.2%) along with a decrease for carbohydrates (minus 0.8%) and cereals (minus 1.7%). This tendency to consume more animal fats and oils, meats and the like slowed down after 1970. However, intakes of proteins, fats, carbohydrates and many other nutrients are highly correlated with each other. In 1983 average salt intake, one of the contributing factors to hypertension, was reduced to 12.4 grams per capita per day from 14.5 grams in 1973.

Keys et al. showed that changes in serum in total cholesterol level can be estimated from the fat composition of the diet. As the Keys et al. "diet score" increases in Japan, the serum total cholesterol level of the average Japanese is expected to increase. In general, epidemiological studies in Japan show that serum total cholesterol is inversely related to cerebral hemorrhage, but the relation of serum total cholesterol to cerebral infarction is not yet significant. Accordingly, the future declining trend in the death rate from cerebral hemorrhage could still be affected by changes in dietary fat composition and increase in serum total cholesterol level.

The prevalence of hypertension, a major risk factor of cerebrovascular disease, has been decreasing appreciably, as shown by the National Surveys on Circulatory Disorders. Epidemiological studies in some communities also show evidence that the incidence or mortality from cerebrovascular disease has been falling along with improvements in the control of hypertension.

The rate of treated hypertensive cases for males in Japan is predicted by univariate regression analyses for 1973 to 1982 to be 524 per 100,000 in 1990 and 572 in 2000, +0.9% per year, and for females it is estimated at 627 in 1990 and 697 in 2000, +1.1% per year. The more favorable age-adjusted death rates from cerebral hemorrhage and infarction for females are due to the higher prevalence of treated hypertensive cases for females than for males. There is no doubt that the progress of medical care for hypertension and hyperlipemia will modify future mortality from cerebrovascular disease.

Univariate regression analyses show that the intake of energy, carbohydrates, protein, and fats and oils per capita per day will be 2011 kcal, 262 g, 76.9 g, and 63.8 g in 1990, respectively, and 1876 kcal, 213 g, 74.2 g, 70.2 g in 2000, respectively, based on results by the National Nutrition surveys from 1973 to 1982. Multiple logistic analyses with carbohydrates, animal proteins, fats and animal fats (and protein and energy, if added) show that recent down trends of age-adjusted death rates from cerebral hemorrhage and infarction are most strongly and significantly related to decreases in the intake of carbohydrates (Table III).

Present trends of crude and age-adjusted death rates from cerebral hemorrhage and infarction will be strongly affected by improved dietary habits, such as less intake of carbohydrates and salt, along with the effects of hypertension control. Further improvements in life style or the control of hypertension will assure the predicted future decrease in deaths from cerebrovascular disease.

It is worth noting that there are few well controlled population studies including quantitative evaluation of a specific and/or multifactorial approach to the control of cerebral stroke, although there are several well designed follow-up studies identifying the risk factors in Japan.

Further studies with simulation analysis will be needed to evaluate comprehensively the relationship between changes in epidemiological factors, such as life styles, public health activities and progress in the control of hypertension, and the projected mortality from cerebral stroke.
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