An Epidemiological Approach to the Relation Between Diet and Cerebrovascular Lesions and Arteriosclerotic Heart Disease

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In Japan cerebrovascular lesions are the most common cause of deaths in contrast to most Western countries, in which heart disease is the most common. Concerning the extraordinarily high mortality for cerebrovascular lesions in Japan, WHO seems to suspect the accuracy of Japanese vital statistics in methods of certification, diagnostic criteria and coding practices. However, such high mortality for cerebrovascular lesions is found not only in Japanese but also in American Negroes especially in the Southern states, and there found some common nutritional deficiency between Japanese nation and American Negroes. In Japan, as well as other Asian countries in which people take an Oriental diet (with more cereals and less animal protein and fats than in the Occidental countries), mortality from arteriosclerotic and degenerative heart disease is lower than in the countries where peoples take Western pattern diet, even though some Asian countries lack in accurate vital statistics.

In the present paper the correlation coefficients between diet and mortality from vascular lesions affecting central nervous system (B 22) and arteriosclerotic and degenerative heart disease (B 26) are computed and discussed for 20 Western countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany (Federal Republic), Israel, Italy, Holland, New Zealand, Norway, Portugal, Sweden, Switzerland, Union of South Africa, United Kingdom, United States of America and Venezuela. Instead of the national dietary consumption the national average supplies (in calorie) per caput per day for 10 foodstuff groups are adopted from the Production Yearbook of FAO, 1960. Corrected death rates from cerebrovascular lesions (B 22) and from arteriosclerotic and degenerative heart disease (B 26) are calculated for the age group 30–69 years from data of 1958 in the Annual Epidemiological and Vital Statistics, 1961. Although the
statistics include data from Ceylon and Japan, these countries are excluded from the data of correlation between diet and the death rate, because both Asian countries are very different from Western countries either in the dietary habit or in the death rates.

MORTALITY FROM CEREBROVASCULAR LESIONS AND ARTERIOSCLEROTIC HEART DISEASE

As shown in Fig. 1, on the corrected death rate from cerebrovascular lesions of 30–69 age group Japanese male is the highest, in contrast with on the death rate from arteriosclerotic heart disease on which Japan and Ceylon are the lowest. The non-white male and female group of the United States are similar to the

![CORRECTED DEATH RATE FOR AGE GROUP 30-69 FROM VASC. LES. AFFECT. ARTERIOSCL. HEART C.N.S. (B 22) DIS. (B 26)](image)

Fig. 1. Corrected death rate for age group 39-69 from vascular lesions affecting central nervous system (B 22) and arteriosclerotic and degenerative heart disease (B 26) for 22 countries.
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Japanese male group with respect to the death rate from cerebrovascular lesions of 30–69 age group. Among European countries, Italy, Germany, Austria, Portugal and Finland show a relatively high death rate from cerebrovascular lesions in male, while Belgium, Holland and Denmark are lower in this respect. Ceylon shows the lowest death rate from cerebrovascular lesions, which seems reasonable when it is remembered that the blood pressure level does not go up with age also in presenile period in Ceylon. It is also remarkable that most countries, except Japan, show a greater sex discrepancy in deaths from arteriosclerotic heart disease than is the case for cerebrovascular lesions.

A high death rate (over 250) from arteriosclerotic heart disease is found in whites and non-whites in the United States, whites of the Union of South Africa, Canada, Australia, New Zealand, England and Wales, and Finland. The death rate of the United Kingdom seems to be a little higher than that of England and Wales, because the death rate is usually higher in Scotland and in Northern Ireland than in England and Wales. It seems there is some meaning that, except for Finland, these are the people generally take British pattern of diet. There are some differences between British pattern of diet and that of the Continent. For instance, in Britain, but not on the Continent countries, some meat is

![Fig. 2. Correlation of death rates between cerebrovascular lesions and arteriosclerotic heart disease by 20 Western countries.](image-url)
generally taken at breakfast. France and Portugal show low mortality from arteriosclerotic heart disease and in that respect are rather similar to Japan and Ceylon.

As shown in Fig. 2, the correlation coefficient of the corrected death rate between cerebrovascular lesions and arteriosclerotic heart disease calculated by 20 nations (excluding Japan and Ceylon) is not on the significance level of P<0.05. However, for females, the coefficient is on the significance level of 0.05<P<0.1, and by male, when Portugal is excluded as an exceptional case, the coefficient comes on the significance level of P<0.05. Therefore, it seems there should be slight positive association of death rates between cerebrovascular lesions and arteriosclerotic heart disease by nations. On the other hand, correlation coefficients of the corrected death rate from cerebrovascular lesions and from arteriosclerotic heart disease between male and female are on the significance level of P<0.001, as shown in Fig. 3. Although there is big difference of mortality for arteriosclerotic heart disease between male and female, there is high correlation by nation, similar to that of mortality for cerebrovascular lesions.

![Correlation of death rates between male and female for cerebrovascular lesions and arteriosclerotic heart disease by 20 Western countries, 1958.](image)

**Fig. 3.** Correlation of death rates between male and female for cerebrovascular lesions and arteriosclerotic heart disease by 20 Western countries, 1958.
NATIONAL AVERAGE FOOD SUPPLIES IN THE CORRESPONDING COUNTRIES

In the Production Yearbook of FAO (1960), national average supplies of foods divided in 10 groups of foodstuffs (cereals, potatoes and other starchy roots, sugar and syrups, pulses and nuts, fruit and vegetables, meat, eggs, fish, milk, and fats and oils) are presented in calories per caput per day mostly on 1948/49–1959/60; estimated total calorie and total and animal protein are also included in these statistics. In the country and region classification, Luxembourg is included with Belgium, England and Wales are included in the United Kingdom together with Scotland and Northern Ireland, these regions having only 12.7% of whole population in the United Kingdom. As for the Union of South Africa, national average food supply seems to be calculated not only for white but also for non-white people which mortality from cerebrovascular lesions and arteriosclerotic heart disease does not appear in the present paper. Similarly, the death statistics from Israel include only Jewish people. Death statistics of Venezuela and New

Fig. 4. Estimated calorie and protein content of national average food supplies per caput per day.
Zealand exclude tribal Indians and Maoris; these are small in number and negligible.

The estimated calorie and protein content of average food supplies is as shown in Fig. 4. It seems reasonable that in the countries in tropic and substropic zones such as Venezuela, Ceylon and Japan, less total calorie is taken than in subfrigid zone such as Scandinavia. Both total protein and animal protein intake are lower in Ceylon, Japan and Venezuela than in other countries, while among European countries Portugal seems lowest in this respect.

As shown in Fig. 5, Union of South Africa has a higher supply of cereals than Japan, notwithstanding other British Commonwealth countries which have a lower supply; this probably reflects the diet of non-white people which accounts for four fifth of the total population of the Union of South Africa. Among European countries, Italy shows the highest national average supply of cereals. Following the Union of South Africa, Japan and Italy the higher national average supplies

![Fig. 5. National average supply of cereals, potatoes and other starchy roots, sugar and syrups, and fats and oils in calories per caput per day.](image)
of cereals occur in Israel and Ceylon.

Most Western countries seem to take more sugar and syrups than do Oriental countries; these foodstuffs, however, account for only small percentage of the national carbohydrate supply averages. As seen in the right side of Fig. 5, Japan, Ceylon, and the Union of South Africa maintain the lowest intakes of fats and oils. As was the case discussed above for carbohydrate intake, the Union of South Africa is probably included in this group because the data from the white and non-white population have been combined.

Pulses and nuts are the main source of vegetable protein. Those nations which take less animal protein usually take more pulses and nuts; see for example Japan, Ceylon and Italy, in Fig. 6. It is natural that the nations which have more sea coast (in proportion to inland area) such as Ceylon, Japan, Portugal and Norway, consume more fish. The countries of the British Commonwealth, the United States and Denmark show higher national average supplies of meat than

![Graph](image-url)

Fig. 6. National average supply of pulses and nuts, meat, eggs, and fish in calories per caput per day.
other countries.

Vegetables and fruit, and milk and milk products are the main source of minerals and vitamins. Although vegetables might be higher evaluated than fruit as the source of minerals, in the Production Yearbook of FAO they are not separated. Japan, Ceylon, Venezuela, Finland, and the Union of South Africa show lower national average supply of vegetables and fruit than other countries, as shown in Fig. 7. However, there are greater differences in the national average supplies of milk and milk products than for vegetables and fruit. Portugal shows the lowest average supply of milk and milk products among Western countries; her national average milk supply is the closest to that of Asian countries, such as Japan and Ceylon. Italy, Union of South Africa, and Venezuela take 100–200 Calories from milk and milk products; France, Belgium and Luxembourg, Germany, and Israel 200–300 Calories; Austria, Denmark, Holland, United Kingdom, and Australia 300–400 Calories; Norway, Sweden, Switzerland, and New Zealand 400–

![Fig. 7. National average supply of vegetables and fruits, and milk and milk products in calories per caput per day.](image-url)
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550 Calories; and Finland 620 Calories.

Table I shows the cross correlation coefficients of 13 subgroups of foodstuffs in the national average supplies which have been calculated from the data from 22 countries. It is natural that there is found high positive correlation between total calorie and total protein, total protein and animal protein, and total calorie and animal protein. Significant correlation is found between total calorie and following foodstuff groups; sugar and syrups (P<0.001), milk (P<0.001), meat (P<0.01), fats and oils (P<0.01), eggs (P<0.05), cereals (P<0.05, negative), pulses and nuts (P<0.05, negative); between total protein and followings; milk (P<0.001), sugar and syrups (P<0.01), meat (P<0.01), pulses and nuts (P<0.01, negative), eggs (P<0.05), fats and oils (P<0.05); between animal protein and followings: cereals (P<0.001, negative), sugar and syrups (P<0.001), meat (P<0.001), milk (P<0.001), fats and oils (P<0.05); between cereals and followings: meat (P<0.01, negative), sugar and syrups (P<0.05, negative), and fats and oils (P<0.05); between potatoes and other starchy roots and fats and oils (P<0.05); between sugar and syrups and meat (P<0.001), and milk (P<0.05); between pulses and nuts and fruit and vegetables (P<0.05, negative); between fruit and vegetables and eggs (P<0.05); between meat and eggs (P<0.05), and milk (P<0.05); between milk and fats and oils (P<0.05).

It should be noted that there is some tendency for nations which consume much sugar and syrups also to consume much meat and milk, and generally they take high total calories. There is also a tendency for nations which consume more cereals to consume less meat, eggs, fats and oils, and sugar and syrups. There is

Table I. Correlations between National Average Supplies of Foodstuff Groups each other

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
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</table>

Notes: n=20, r=.423, P=0.05; r=.537, P=0.01; r=.652, P=0.001.
no significant correlation between national average supply of fish and that of other foodstuff groups, probably because the amount of fish consumed is of little significance as a source of animal protein and total calorie in most countries except Japan and Ceylon.

**CORRELATION BETWEEN NATIONAL FOOD SUPPLIES AND MORTALITY FOR CEREBROVASCULAR LESION AND ARTERIOSCLEROTIC HEART DISEASE**

Table II shows the correlation coefficients between the two disease entities (arteriosclerotic heart disease and cerebrovascular lesions—both subdivided by sex) and the estimated national average supplies (divided into 13 subgroups). Correlations are based on 20 countries excluding Japan and Ceylon which in both mortality and dietary custom differ from Western countries.

**TABLE II. Correlation between National Average Food Supplies and Corrected Death Rate for 30–69 Age Group from Cerebrovascular Lesions and Arteriosclerotic Heart Disease by 20 Countries.**

<table>
<thead>
<tr>
<th>Calorie, protein, and foodstuff groups</th>
<th>Correlation with mortality from cerebrovascular lesions</th>
<th>Correlation with mortality from arteriosclerotic heart disease</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>male</td>
<td>female</td>
</tr>
<tr>
<td>Total calorie</td>
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<tr>
<td>Total protein</td>
<td>-.165</td>
<td>-.138</td>
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<tr>
<td>Animal protein</td>
<td>-.245</td>
<td>-.137</td>
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<tr>
<td>Cereals</td>
<td>-.505</td>
<td>.485</td>
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<tr>
<td>Potatoes and other starchy roots</td>
<td>-.306</td>
<td>-.241</td>
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<tr>
<td>Sugar and syrups</td>
<td>-.351</td>
<td>-.118</td>
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<tr>
<td>Pulses and nuts</td>
<td>-.102</td>
<td>-.188</td>
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<tr>
<td>Fruit and vegetables</td>
<td>-.076</td>
<td>-.282</td>
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<tr>
<td>Meat</td>
<td>-.189</td>
<td>-.301</td>
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<tr>
<td>Eggs</td>
<td>-.286</td>
<td>-.212</td>
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<tr>
<td>Fish</td>
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<td>.044</td>
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<tr>
<td>Milk</td>
<td>-.177</td>
<td>.052</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>-.491</td>
<td>-.347</td>
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</tbody>
</table>

Note: n=20, r=.423, P=0.05; r=.537, P=0.01; r=.652, P=0.001

As seen in Table II, significant correlations are found between the corrected death rate from cerebrovascular lesions and national average supply of following foodstuff groups: cereals (male, P<0.02; female, P<0.05), fats and oils (male, P<0.05, negative; female, P<0.05) (Figs. 8, 9). Although by other foodstuff groups no significant correlation is found between them and the death rate, there are some exceptional cases in these correlation, and when they were excluded the correlation coefficient comes to the significance level. If Finland be excluded, correlation coefficients between the death rate and national average supplies of following foodstuff groups reach the significance level of P<0.05: potatoes and other
Fig. 8. Correlation between death rate from cerebrovascular lesions and national average supply of cereals by 20 Western countries.

Fig. 9. Correlation between death rate from cerebrovascular lesions and national average supply of fats and oils by 20 Western countries.
Fig. 10. Correlation between death rate from cerebrovascular lesions and national average supply of potatoes and other starchy roots by 20 Western countries.

Fig. 11. Correlation between death rate from cerebrovascular lesions and national average supply of milk by 20 Western countries.
starchy roots (female, n=19, r=-0.456), milk (male, n=19, r=-0.455), and fats and oils (female, n=19, r=-0.473) (Figs. 9, 10, 11).

For statistical test, correlation coefficient is calculated between the death rate and national milk product per caput in 1954 which was computed by the author from the data which appeared in Statistical Yearbook of United Nations,1955, for 15 Western countries: Austria, Belgium, Canada, Czechoslovakia, France, Germany, Holland, Italy, Norway, Portugal, Sweden, Switzerland, Union of South Africa, United Kingdom, United States of America, Denmark, Finland, Australia, New Zealand and Venezuela are excluded, since they show conditions more or less different from those other countries. Negative correlations are on the significance level of P<0.001 by male and of P<0.01 by female (Fig. 12).

Correlation coefficients between the corrected death rate from arteriosclerotic heart disease and national average food supplies are significant for the foodstuff groups of (1) potatoes and other starchy roots (male, P<0.01; female, P<0.001;

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Fig. 12. Correlation between milk production and death rate from cerebrovascular lesions.
both negative correlations), and (2) sugar and syrups (male, \(P<0.01\); female, \(P<0.05\)) (Figs. 13, 14). Although the coefficient between the death rate from arteriosclerotic heart disease and national average supplies of meat and eggs are not on the significance level by themselves, when these are added, the coefficient reaches the significance level of \(P<0.05\) in male (Fig. 15). The correlation coefficient between the death rate and the national average supply of fish is not significant, though it seems there is some tendency of negative correlation especially for females (\(P<0.1\)). Although Jolliffe and Archer\(^8\) distinguished that the intake of saturated types of fat was most important of all the factors considered in accounting for the differences in coronary heart disease death rates between countries, in the present data fats and oils are not separated,

![Fig. 13. Correlation between death rate from arteriosclerotic heart disease and national average supply of potatoes and other starchy roots by 20 Western countries.](image1)

![Fig. 14. Correlation between death rate from arteriosclerotic heart disease and national average supply of sugar and syrups by 20 Western countries.](image2)
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Fig. 15. Correlation between death rate from arteriosclerotic heart disease and national average supply of meat and eggs by 20 Western countries.

Fig. 16. Correlation between death rate from arteriosclerotic heart disease and total calorie content of national average food supplies by 20 Western countries.

and the correlation coefficients between them and arteriosclerotic heart disease death rates are not on the significance level. If the Union of South Africa be excluded, the correlation coefficients between the death rate and national average supplies of total calories (male, $P<0.05$) and of following foodstuff groups reach the significance level: animal protein (male, $P<0.01$), eggs (male, $P<0.001$; female, $P<0.01$), milk (male, $P<0.02$) (Figs. 16, 17, 18 and 19).

Although correlation coefficients do not demonstrate causality, it appears that; those nations which consume more cereals, less fats and oils, less milk, and less potatoes and other starchy roots seem to have more deaths from cerebrovascular lesions, while those nations which consume more sugar and syrups, more animal protein, more meat and eggs, more milk, and less potatoes and other starchy roots
Fig. 17. Correlation between death rate from arteriosclerotic heart disease and animal protein content of national average food supplies by 20 Western countries.

Fig. 18. Correlation between death rate from arteriosclerotic heart disease and national average supply of eggs by 20 Western countries.

seem to have more deaths from arteriosclerotic heart disease.

**DISCUSSION**

It would not be without reason to suspect methods of certification, diagnostic criteria and coding practices in Japan where the mortality for cerebrovascular lesions is too high. The proportion of autopsied to all deaths is really lower in Japan than in Western countries. According to Ueda9) in the Department of Vital Statistics and Investigation, Welfare Ministry of Japan, who had studied
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Fig. 19. Correlation between death rate from arteriosclerotic heart disease and national average supply of milk by 20 Western countries.

the multiple cause of 44,255 deaths in Tokyo in 1955, only 4.6% of all deaths was autopsied, in contrast to 20.2% in England and Wales, and 35.8% in Hamburg. According to this study, 37.1% of 7,123 deaths from cerebral hemorrhage had hypertension as secondary cause, while 11.6% of them had sclerotic arteries. Of 624 deaths from cerebral embolism and thrombosis, 13.5% had arteriosclerosis, 6.6% sclerotic arteries, and 9.6% hypertension.

There is some evidence for high morbidity and mortality of cerebrovascular lesions in Japan, where there are nearly 800 public health centers, each of which services a population of 100,000 to 200,000. Under the control of Akita Public Health Center, there is a rural district consisting of several farm villages in which the inhabitants are supported mainly by rice cultivation. In this farm district of about 44,000 population, the number of persons paralysed following stroke was investigated in 1959; the population was divided into five year age groups. It was found that 6.0% of 50-54 year age group and 10.0% of 55-59 had been paralysed. Akita Prefecture shows the highest morbidity and mortality from cerebrovascular lesions in all Japan.

In a single rice field area under the control of a public health center near Sendai, there were 863 deaths from cerebrovascular lesions (containing secondary cause) for 1955–1960, and all except one were diagnosed before death. It seems uncommon in the present Japan that cerebral hemorrhage or other cerebrovascular lesions is described as a cause in a death certificate without any diagnosis before death.

Kondô, who investigated the relation between dietary customs and longevity on hundreds of farming and fishing villages all over Japan, concluded that inhabitants of farming villages where people ate too much rice and too little vegetables generally showed low longevity rate (proportion of total population which is aged 70 and over). In Japan longevity rate of a village is mainly
influenced by mortality of the middle-aged group in which the dominant cause of death is cerebrovascular lesions. This conclusion is in accordance with our result that nations which consume more cereals seem to have more deaths from cerebrovascular lesions. Even though there is no toxic effect of cereals, when cereals, especially cleaned cereals, occupy the major part of food consumed, the diet should be lacking in some essential nutrients such as minerals and vitamins.

According to the result of National Nutritional Survey of Japan in 1959, the nation takes 71.5% of its total calories from cereals especially from rice (58.0% of total calorie). The nutrient values of the average daily dietary intake of the Japanese nation in 1959 were: total calorie, 2,117 Cal., 69.3 gm. of protein (23.5 gm. animal protein), 23.8 gm. of fats and oils, 406 gm. of carbohydrate, 385 mg. of calcium, 3,202 I.U. of vitamin A, 1.05 mg. of vitamin B1, 0.74 mg. of vitamin B2, and 78 mg. of vitamin C. It is clear that no small parts of Japanese, especially in rural districts, are lacking in calcium and some kinds of vitamin. As the symptoms of deficiency of these vitamins, anemia, angular lesions of mouth, follicular keratosis, loss of knee jerks, calf tenderness and edema were found respectively in 2.4%, 5.7%, 2.9%, 10.9%, 6.2% and 2.7% of the population investigated by the Japanese National Nutritional Survey in 1959.

The nutrient deficiency of Japanese diet is very similar to that of the people in the Southern states of the United States, especially Negroes who show the nearest mortality in cerebrovascular lesions to the Japanese nation. Calcium is the common deficient mineral in the diet of both races. Although there is no experimental verification on the relationship between calcium deficiency and cardiovascular disease, Schroeder and Morris et al. epidemiologically proved the association between the mortality from cardiovascular disease and minerals, especially calcium and magnesium, in drinking water. In point of calcium intake, intake from food should be equal or more than intake from drinking water. Vitamin A, C and B-complex also seem to be common deficient vitamins to both races.

Contrary to her high mortality for cerebrovascular lesions, Japan is one of the lowest countries in mortality for arteriosclerotic heart disease. Japanese nation consumes the smallest amount of sugar and syrups among the nations which have been surveyed here, they also consume the smallest amount of fats and oils. As the source of animal protein, they consume somewhat more of fish than meat and eggs. Those peculiar dietary custom seems to be one of the factors which keep low mortality from arteriosclerotic heart disease for Japanese nation.

SUMMARY

Correlation coefficients were calculated between national average supplies of 10 foodstuff groups and corrected death rate for 30-69 age group from cerebrovascular lesions and arteriosclerotic heart disease, among 20 Western countries.
Results follow:

1. No significant correlation of the corrected death rates is found between cerebrovascular lesions and arteriosclerotic heart disease.
2. There are high correlation between male and female in both corrected death rates for cerebrovascular lesions and for arteriosclerotic heart disease.
3. There are some correlations among foodstuff groups by nations, for instance, sugar and syrups-meat-milk (positive correlation), and cereals-meat (negative correlation).
4. Nations which consume more cereals and less fats and oils tend to have a high mortality from cerebrovascular lesions.
5. Nations which consume less potatoes and other starchy roots, more sugar and syrups and probably more meat, eggs and milk tend to have a high mortality for arteriosclerotic heart disease.

These results are discussed on the data of peculiar condition in Japan.

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