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Statistical Analysis of the Relationships between Salt Intake, Hypertension and Heart Diseases Based on National Surveys in Japan

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ABSTRACT

The relationship between salt intake and hypertension has been researched since Dahl's epidemiological study. Recently, the Intersalt Study revealed that epidemiologically there was little if any relationship in the developed countries; however, a weak relationship was identified if certain 'no salt' cultures in the world were included. In this paper, the relationships between salt intake and mortality caused by various diseases are analyzed based on many national statistical surveys related to the health policy in Japan.

Firstly, the trends in salt intake and death rates of some diseases are described. Salt intake decreased from 13.5 to 12.2 g/day during a fifteen year period. However, salt intake has been constant in the past five to six years. On the other hand, the death rates due to hypertension, heart, cerebrovascular and stroke diseases have decreased almost linearly since 1965.

Secondly, some analytical studies were conducted to clarify the relationships between salt intake, hypertension and other diseases. These studies were based on the National Nutrition Survey with Vital Statistics, and Patients Survey. Consequently, salt intake had an inverse effect on the death rates related to heart and hypertensive diseases and the in-patient rate with hypertension. Although salt intake had a direct effect on the death rates due cerebrovascular disease and stroke, this relationship become inverse in the case of old age (>80 years) with stroke.

Thirdly, the prevalence of disease on out-patients and in-patients was studied related to salt intake. However, this study did not reveal any correlations.

As a result, it was concluded that the relationships between salt intake and the various diseases attributed to it, could not be confirmed by these analytical studies.

INTRODUCTION

Many studies of the relationship between salt intake and hypertension have begun with the epidemiological observation of Dahl et al. (1954) who hypothesized that salt was the cause of hypertension. Many researchers have attempted to prove the salt hypothesis in terms of epidemiological, pathological, clinical, and experimental animal studies. In the course of these studies, many useful experimental models such as SR, SSR (Dahl et al., 1962), SHR (Okamoto et al., 1963) and SHR-SP (Okamoto et al., 1973) rats have been developed.

In addition, Kawasaki et al. (1978) demonstrated salt sensitive hypertension in man. However, the relationship between salt and blood pressure is so complicated that the hypothesis has still not been proved. Finally, the Intersalt Study was carried out in order to confirm the hypothesis with a worldwide, large scale and a careful protocol of epidemiological research (Intersalt Cooperative Research Group, 1988; Rose and Stamler, 1989). Nevertheless, the hypothesis could not be clearly proved. Based on the results of the Intersalt Study, many scientists have considered the problems of salt and health, and made suggestions concerning future research (Luft, 1989; Horan and Mockrin, 1990; Cowley, Jr., 1991).

It has been stated that the high intake of salt by the Japanese may have a correlation with the high incidence of hypertension in the country. In order to formulate health policies, the Ministry of Health and Welfare of Japan (MHW) has conducted many surveys such as the National Nutrition Survey, which included studies of salt intake, Vital Statistics, and a Patient Survey. Further, the MHW set 10 g NaCl/day as the dietary salt goal (this value is de-

fined as safe and adequate intake of salt.) in 1978. The MHW is currently trying to decrease salt intake and is taking steps to raise public awareness about the benefits of reduction of salt intake through a health guidance service in medical institutions and public health offices, as well as in schools.

Despite many statistical data and a strong intent to reduce salt intake, there are few studies relating diseases to salt intake. By citing one or two examples, Hirata et al. (1983) reported the trend of death rates caused by leading diseases in relation to salt intake in the Japanese. These authors pointed out many direct or inverse relationships of salt intake with diseases, including hypertensive, cerebrovascular and heart disease. Yamaguchi et al. (1990) reported the risk of gastric cancer related to salt intake on the basis of the National Nutrition Survey. However, there are few analytical reports concerning the relationships between salt intake and the mortality rates of various diseases for the Japanese.

In this report, I first discuss the trends of salt intake and death rates caused by certain diseases, such as hypertension, heart disease, cerebrovascular disease and stroke. Then, I intend to clarify the effect of salt intake on those death rates. In the next step, I will demonstrate the prevalence of diseases in outpatients in terms of their salt intake. In general, this epidemiological study could not reveal any relationships between salt intake and the diseases studied, namely hypertension, cerebrovascular disease, stroke and heart disease.

STATISTICAL MATERIALS AND METHOD

Statistical surveys

Dietary salt intake

The MHW has conducted the National Nutrition Survey every year. The scale is shown in Table 1 (Public Health Bureau, 1976–1990). Dietary salt intake is one of the items surveyed in the National Nutrition Survey. For this research, households are sampled and asked to weigh all foods eaten by its family members for three days consecutively except on holidays. Then, the sodium content in various foods is summed up on the base of "Standard Tables of Food Composition in Japan" (1983). The value for sodium is converted into that of sodium chloride by multiplying sodium in the food by the coefficient 2.54. The salt intake is reported by area block shown in Fig. 1 and Table 2. Table 2 shows the results of salt intake in the population in 1989 for reference.

TABLE 1

Scale of the National Nutrition Survey

Year	Areas	Households	Subjects
1975	300	6,100	22,000
1976	368	7,500	26,000
1977	368	6,000	20,500
1978	368	6,000	21,000
1979	300	6,000	21,000
1980	300	6,400	25,000
1981	300	7,000	20,000
1982	300	7,000	20,000
1983	300	7,000	20,000
1984	300	7,000	20,000
1985	300	7,000	20,000
1986	300	7,000	20,000
1987	300	7,000	20,000
1988	300	6,000	20,000
1989	300	6,000	20,000
1990	300	6,000	20,000

Note: Values for households and subjects are round numbers.

TABLE 2

Area block for the data of salt intake and population in 1989

Sign	Area block	Prefectures included	Population (000)
A	Hokkaido	Hokkaido	5,660
B	Tohoku	Aomori, Iwate, Miyagi, Akita, Yamagata, Fukushima	9,734
C	Kanto I	Saitama, Chiba, Tokyo, Kanagawa	31,243
D	Kanto II	Ibaragi, Tochigi, Gunma, Yamanashi, Nagano	9,676
E	Hokuriku	Niigata, Toyama, Ishikawa, Fukui	5,575
F	Tokai	Gifu, Aichi, Shizuoka	12,268
G	Kinki I	Kyoto, Osaka, Hyogo	16,499
H	Kinki II	Nara, Wakayama, Shiga, Mie	5,418
I	Chugoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi	7,731
J	Shikoku	Tokushima, Kagawa, Ehime, Kochi	4,213
K	Kitakyushu	Fukuoka, Saga, Nagasaki, Ohita	8,453
L	Minamikyushu	Kumamoto, Miyazaki, Kagoshima, Okinawa	6,041

Fig. 1. Area blocks for the National Nutrition Survey (see Table 2 for an explanation of the signs A to L..

Vital Statistics

Vital Statistics have been published by the Statistics and Information Department, Minister's Secretariat, Ministry of Health and Welfare (SID-MS-MHW) every year. These include information on live births, deaths, infant deaths, foetal deaths, marriage and divorces in every prefecture. In the Vital Statistics, the cause of death is classified by disease. The special report of this survey has been issued every five years as age-adjusted death rates by leading causes of death, when a national census is taken. I selected the hypertension, cerebrovascular disease, stroke and heart disease from these report (SID-MS-MHW, 1983, 1988). In this paper, cerebrovascular disease included cerebral hemorrhage, cerebral infarction and other cerebrovascular diseases as well. Hypertensive diseases included hypertensive heart disease and other hypertensive diseases. Heart disease included chronic rheumatic heart disease, ischemic heart disease, pulmonary circulatory disease and other types of heart diseases, such as endocardial disease and heart failure.

Patient Survey

The SID-MS-MHW conducted the Patient Survey every three years since 1984 (SID-SM-MHW, 1986 and 1989). It studied the number of out-patients and in-patients who suffered from various diseases in every prefecture. Medical institutions such as hospitals, clinics and dental clinics from all over Japan were selected by stratified random sampling. These sample numbers were 2,377, 2,905 and 771 in 1984, and 3,080, 5,875 and 986 in 1987, respectively. The subjects of investigation were those patients who utilized these institutions.

Method

Dietary salt intake and Patient Survey in 1987 were reported by area block. However, other surveys were given by prefecture. Therefore, to normalize these, I summed the data from the prefectures covered by the same area block. I next calculated the mean value by each area block.

RESULTS AND DISCUSSION

Trends of decreasing salt intake

The MHW has begun to survey trends of dietary salt intake since 1972. Table 3 shows the decreasing trends of the dietary salt intake by area block since 1975. The highest salt intake block was the Tohoku area and the lowest was the Kinki I. The national average has decreased from 13.5 to 12.5 g in the last fifteen years. Values for dietary salt intake have remained almost at the same level over the last six years except for 1987. According to the recent announcement from the Health and Welfare Ministry, salt intake in 1990 leapt from 12.2 to 12.5 g equivalent to the level in 1981. They concluded that this increase was caused by the increase of eating out (see Fig. 2). The previously observed decrease in salt intake has not been observed in recent years. On the contrary, an increasing trend has recently appeared.

At any rate, these values are still above the dietary salt intake goal set in 1979. Sakata et al. (1990) discussed a significant, positive correlation between sodium and urea-nitrogen (protein). These authors recognized no further reduction of salt intake and therefore proposed a new strategy which included protein intake restriction, as a means of reducing further salt intake by the Japanese.

Figure 2 shows the trend of the population and national dietary habits. The ratio of 1975 was made equal to 1 as a baseline in order to compare the ratios for each year. The population increased by 10% during these fourteen years. The sales of salt consumed in households have not changed, although the sales have fluctuated every year except in 1975 and 1990. However, according to the Comprehensive Time Series Report on the Family Income and Expenditure Survey 1947–1986 (Statistics Bureau Management and Co-ordination Agency Japan, 1988), the processed food cost in the family budget has increased steadily and 'eating out' costs have risen rapidly.

The dietary salt intake decreased by 10% over the last fourteen years until 1989. Assuming that the consumption of salt was constant, the decreased ratio of salt intake was equivalent to the increased ratio of population. However, Hashimoto (1990) reported that salt consumption for food and population

TABLE 3

Trend of dietary salt intake by area block

Year	A	B	C	D	E	F	G	H	I	J	K	L	Average
1975	–	–	–	–	–	–	–	–	–	–	–	–	13.5 (14.0)
1976	–	–	–	–	–	–	–	–	–	–	–	–	13.7 (14.2)
1977	–	–	–	–	–	–	–	–	–	–	–	–	13.4 (13.7)
1978	–	–	–	–	–	–	–	–	–	–	–	–	13.4 (13.8)
1979	14.0	15.0	12.6	15.8	14.0	12.5	11.1	11.8	12.6	13.0	13.1	14.5	13.0 (13.1)
1980	14.4	15.8	12.7	15.4	14.2	11.8	10.9	11.5	12.3	12.0	13.0	13.6	12.9 (13.0)
1981	12.9	14.8	12.6	14.3	14.0	11.5	10.9	10.5	11.6	11.5	12.6	13.0	12.5
1982	12.8	14.5	12.1	13.5	13.4	11.4	11.2	11.9	12.4	12.1	12.4	12.7	12.3
1983	13.5	14.6	12.4	13.9	13.9	11.4	11.1	11.5	11.6	11.5	12.7	12.6	12.4
1984	14.0	13.9	12.2	13.7	12.9	11.4	10.9	11.2	12.3	11.4	11.9	11.1	12.2
1985	12.9	14.0	12.3	12.8	13.4	11.5	10.8	11.0	11.4	11.4	12.3	11.1	12.1
1986	12.8	14.0	11.9	13.3	12.6	11.4	11.0	10.8	11.3	11.4	12.7	12.8	12.1
1987	12.6	13.0	11.7	12.6	12.6	11.1	10.5	11.1	11.9	11.2	11.7	11.6	11.7
1988	11.7	14.7	12.2	13.6	13.1	11.9	11.5	11.0	11.6	11.5	11.8	11.6	12.2
1989	13.0	13.9	12.0	13.1	13.0	11.9	11.1	11.7	12.2	12.0	12.2	11.8	12.2
1990	12.7	13.5	12.5	13.6	12.8	12.1	11.8	13.4	12.5	12.3	11.6	13.0	12.5

Note: See Table 2 for an explanation of the signs A to L. Parenthesized values were revised in 1981.

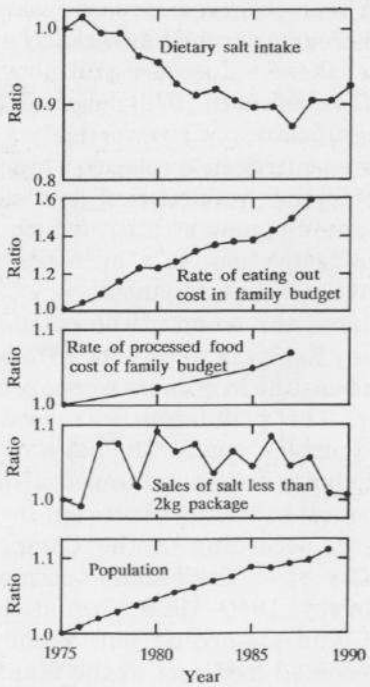

Fig. 2. Trends of population increase and dietary life.

rose about by 4 and 13%, respectively, in the last fifteen years since 1973. As a result, the actual salt intake may not have decreased as much as the statistics indicate.

Decreasing trends of diseases

Figure 3 shows the trend of age-adjusted death rates by cerebrovascular, heart and hypertensive diseases as well as the trend of dietary salt intake and its goal. These diseases have decreased almost linearly since 1965. These trends seem to be independent of the trend of decreasing dietary salt intake. The decreasing incidence of these diseases began ten years prior to the announcement about salt intake. Additionally, these trends have not changed, even after the salt reduction program from 1975. Accordingly, it is possible that they were not

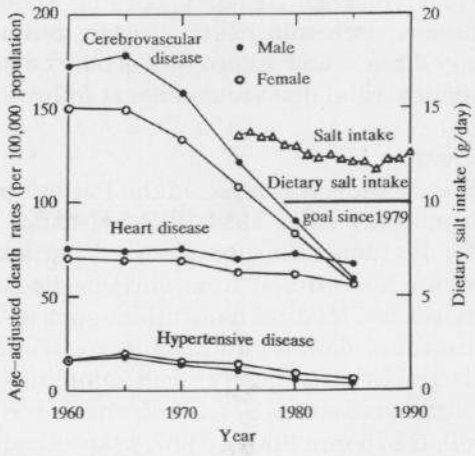

Fig. 3. Trends of age-adjusted death rates by cerebrovascular and hypertensive diseases and dietary salt intake.

related to salt intake at all. The probable cause of the decreasing mortality may be the improvement in Japanese dietary habits and medical treatment beginning about twenty years after the Second World War.

As shown in Table 3, there are wide regional variations in salt intake. It is interesting to compare the trend of some diseases between the highest and the lowest salt intake areas. As Fig. 4 shows, it is clear that the highest salt intake block, Tohoku, shows higher age-adjusted death rates than the lowest salt intake block, Kinki I, both in terms of cerebrovascular and stroke diseases. However, the values of death rates in the two blocks have rapidly become closer, although the salt intake in those areas has remained parallel. On the other hand, Tohoku had a rather lower death rate than Kinki I, in terms of both heart and hypertensive diseases. This fact is entirely contrary to what has been said previously and what has been believed until today.

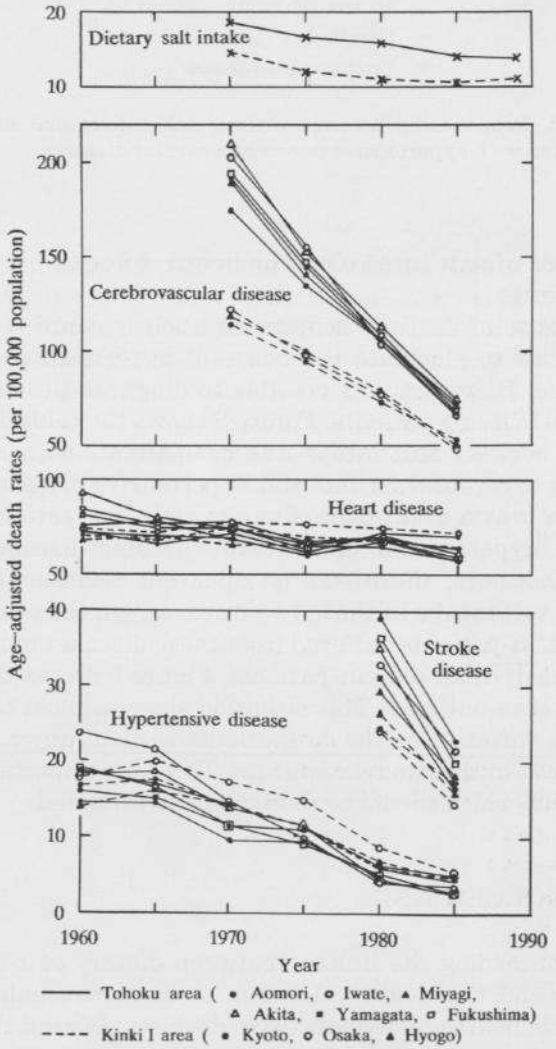

Fig. 4. Comparison of death rates due to several diseases between the highest and the lowest salt intake areas.

Effect of salt intake on the death rates

In order to observe these relationship in more detail, the death rates were plotted against salt intake in Fig. 5. From this figure it is clear that salt intake had a direct effect on cerebrovascular and stroke diseases, but an inverse effect on heart and hypertensive diseases. However, none of them were statistically not significant ($p < 0.01$). Cerebrovascular disease, including stroke, seemed to have a relationship with salt intake. Cerebrovascular disease was especially significant ($r = 0.61$, $p < 0.05$). However, stroke showed a robust relationship with salt intake.

The special report (SID-MS-MHW, 1983 and 1988) of Vital Statistics gives the death rates by 5-year age groups. I discovered a positive correlation for two diseases with salt intake in the 5-year age groups. Firstly, Fig. 6 shows the death rates due to cerebrovascular disease in 1980 and 1985 (Hashimoto, 1991). The death rates increase with increasing age. However, the trends were almost the same in each group. Next, Fig. 7 gives the case of stroke disease (Hashimoto, 1991). It seems to show almost the same tendency as that seen for cerebrovascular disease. However, the positive correlation becomes weaker with increasing age, and the oldest age group had an inverse trend with salt intake. This trend is consistent with current general concepts.

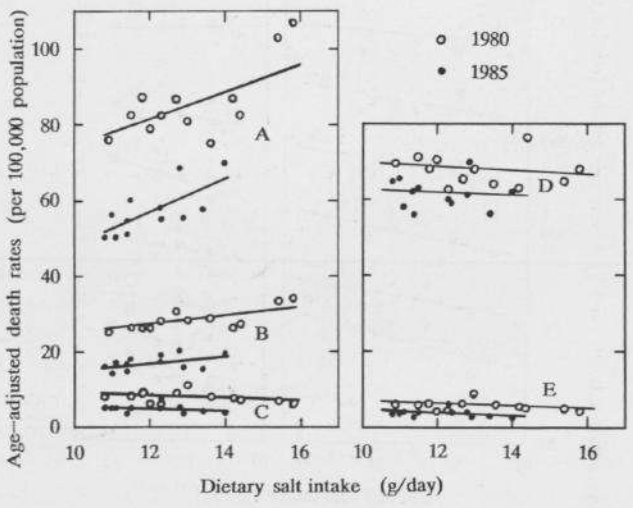

Fig. 5. Relationships between dietary salt intake and several diseases. A. Cerebrovascular disease. B. Stroke disease. C. Hypertensive disease. D. Heart disease. E. Hypertensive heart disease.

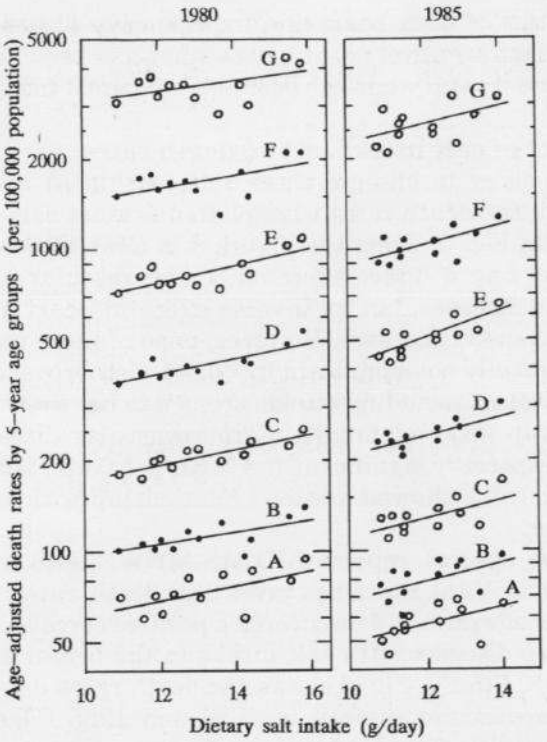

Fig. 6. Relationship between dietary salt intake and death rates by cerebrovascular disease by 5-year age groups in 1980 and 1985. A. 50–54 year age group. B. 55–59. C. 60–64. D. 65–69. E. 70–74. F. 75–79. G. 80–.

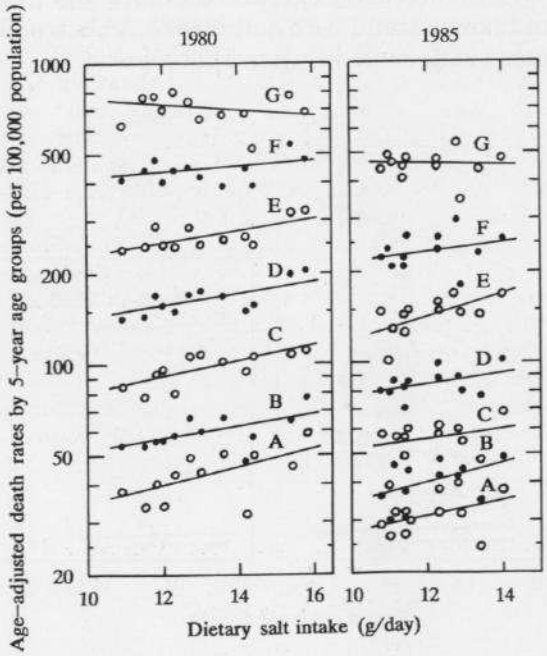

Fig. 7. Relationship between dietary salt intake and death rates by stroke disease by 5-year age groups in 1980 and 1985. A. 50–54 year age group. B. 55–59. C. 60–64. D. 65–69. E. 70–74. F. 75–79. G. 80–.

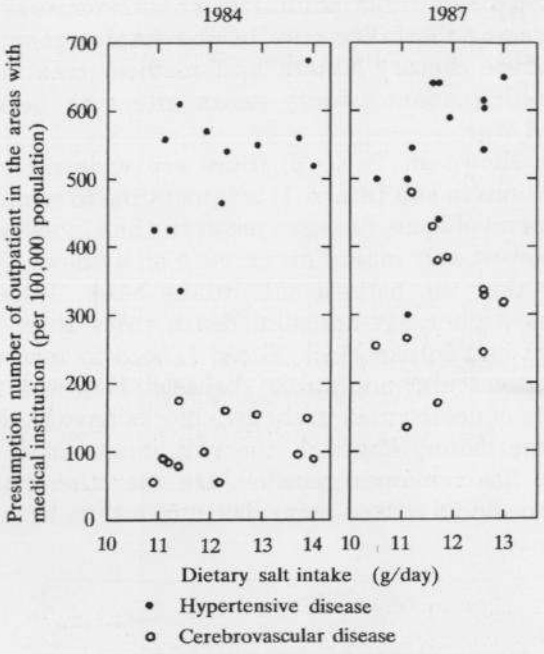

Fig. 8. Relationship between dietary salt intake and out-patients with hypertensive or cerebrovascular diseases.

Effect of salt intake on the occurrence of patients

Cause of death is sometimes unclear, since it is difficult to elucidate the cause of hypertension or stroke. However, it is possible to diagnose the diseases in living patients. Figure 8 shows the relationship between salt intake and out-patients with respect to cerebrovascular and hypertensive diseases. There was a great deal of variation in the patients with hypertension and cerebrovascular diseases. Furthermore, there was no apparent relationship with salt intake in these two diseases. On the other hand, in-patients suffered from these diseases more seriously than did out-patients. Figure 9 shows the case of in-patients. This situation shows almost the same variation as the out-patients without any correlation in the two relationships. These are important results, which should be thoroughly investigated.

CONCLUSIONS

Concerning the linkage between dietary salt intake and the death rates due to cerebrovascular, stroke, heart and hypertensive diseases, I found the following results from the statistical analyses of data published in Japan:

(1) Salt intake has an inverse relation to the death rates due to heart and hypertensive diseases.

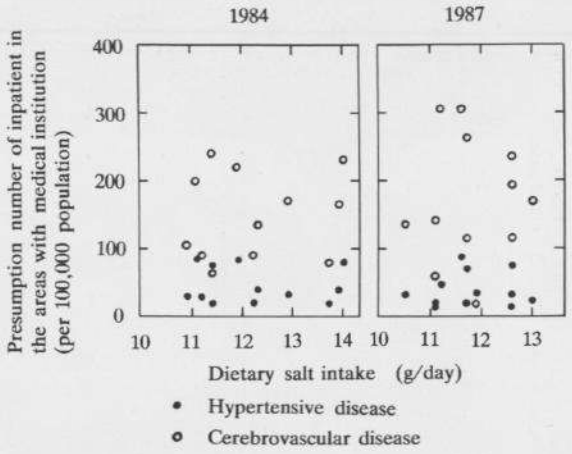

Fig. 9. Relationship between dietary salt intake and inpatients with hypertensive or cerebrovascular diseases.

(2) High salt intake positively correlates with cerebrovascular disease ($r = 0.61$, $P < 0.05$) and stroke.

(3) An inverse correlation existed in a group of the patients with stroke more than 80 years of age.

(4) There were no relationships between salt intake and cerebrovascular and hypertensive diseases in out-patients and in-patients.

(5) Overall, this study did not show any positive correlation between salt intake and some vascular diseases such as hypertension, cerebrovascular disease, stroke and other heart diseases.

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