A Study of Influence of Brushing Teeth, Smoking, and Diabetes on Consultation Rate for Periodontal Disease in Japan

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Abstract

This is a study about how brushing teeth and smoking as lifestyle, and diabetes as a lifestyle-related disease influence the consultation rate for periodontal disease in Japan.
The method is panel analysis with data by prefecture from the 1999 and 2002 statistical surveys in Japan. Dependent variables are the consultation rate for gingivitis and periodontal disease.
The rate of smoking and the rate of diabetes showed significant correlations with the consultation rate for periodontal disease for all ages. Though the annual amount spent on toothbrushes per household showed a significant correlation, it was not as strong as diabetes. The rate of smoking showed no significant correlation with the consultation rate for people over 70 years old. The results suggest that medical expenses for dental care can be reduced by modifying lifestyle.

INTRODUCTION

In Japan, improvement in national health insurance is now an important issue. Therefore, analyzing factors influencing on illnesses and clarifying the relationship with medical expenses are required in all medical fields including dentistry.

Typical dental diseases are caries and periodontal disease, and both diseases are closely connected with lifestyle. Periodontal disease had the relationship with smoking as lifestyle[1,2,3,4,5,6,7,8]. Periodontal disease had the relationship with diabetes as a lifestyle-related disease[9,10,11,12]. However, these reports are based on analysis from a medical viewpoint.

Periodontal disease had the relationship with smoking and diabetes from an economical viewpoint[13]. But there are few similar researches both in the foreign countries and in Japan. To keep good financial condition of health insurance, however, it is very important to analyze the relationship between periodontal disease and lifestyle from an economical viewpoint.

In this paper, an economical index is the consultation rate for periodontal disease, because the consultation rate has the relationship with medical expenses. I analyze how brushing teeth and smoking as lifestyle, and diabetes as a lifestyle-related disease influence on the consultation rate for periodontal disease.

MATERIALS AND METHODS

The sources of the data used in this study were “Patient Survey” (Ministry of Health, Labour and Welfare), “Family Income and Expenditure Survey” (Ministry of Internal Affairs and Communications), “Survey of Medical Institutions” (Ministry of Health, Labor and Welfare), “Report on Health Center Activities and Health Services for the Aged” (Ministry of Health, Labor and Welfare), and “Social Indicators by Prefecture” (Ministry of Internal Affairs and Communications).[a],[b] In considering availability, the data for the analysis were by prefecture in 1999 and 2002. However, the data only from “Family Income and Expenditure Survey” were the prefectural capitals' data. The number of prefectures is 47. Total number of samples was 94.

Data from “Family Income and Expenditure Survey” were the annual amount spent on toothbrushes per household, and were standardized in 1999 to the level in 2002 with the consumer price index.[c] Hereafter, this data was described as “TOOTHBRUSH”.

Data from “Patient Survey” were the number of people who consult a doctor for gingivitis and periodontal disease per

100,000 people for all ages and per 100,000 people over 70 years old, as the consultation rate. Hereafter, the consultation rate of people for all ages was described as "PERIO". The consultation rate of people over 70 years old was described as "PERIO70".

Data from "Survey of Medical Institutions" were the number of dental chairs, and calculated the number of chairs per 100,000 people. Hereafter, this was described as "CHAIR".

Data from "Report on Health Center Activities and Health Services for the Aged" were the number of participants in short educational courses about dental disease, and were calculated the number of participants per 100,000 people over 40 years old. Hereafter, this was described as "EDUCATION". In basic health checkups, there are medical examination interviews including questions about smoking habits. I calculated the smoking rate from the data of the number of people smoking cigarettes in 2000 and the number of people smoking 20 cigarettes or more a day in 2003. I calculated the smoking rate in 1999 and 2002 by linear interpolation. Hereafter, it was described as "SMOKING". I also calculated the number of participants per 100,000 people over 40 years old from the data of the number of participants in checkups for periodontal disease and the population over 40 years old. However, since the data in 1999 was incomplete, I substituted the data from 2000. The data in 2002 was complete. Hereafter, this was described as "CHECKUP". I used the number of participants in checkups for diabetes and the number of people over 70 years old who needed medical treatment in 2000 and 2002, and calculated the diabetes rate. However, I calculated the diabetes rate in 1999 by linear interpolation from the data in 2000 and 2002. Hereafter, this was described as "DIABETES".

From "Social Indicators by Prefecture" I used the income per person. Hereafter, this was described as "INCOME". I used the population rate classified according to age. The rate of people over 40 years old was described as "POPULATION40"; the rate of people over 50 years old, "POPULATION50"; the rate of people over 60 years old, "POPULATION60"; the rate of people over 70 years old, "POPULATION70"; the rate of people over 80 years old, "POPULATION80". Furthermore, I calculated the population per inhabitable square kilometer in 2002. Hereafter, this was described as "DENSITY".

I used "PERIO" and "PERIO70" in 1999 and 2002 as the dependent variables. As the basic independent variables, I used "TOOTHBRUSH", "SMOKING", "EDUCATION", "CHECKUP", "INCOME", "CHAIR", and "DENSITY". I added one population rate variable to the basic independent variables, and estimated the models. Namely I estimated the model including "POPULATION40", the model including "POPULATION50", the model including "POPULATION60", the model including "POPULATION70", and the model including "POPULATION80".

I also estimated the model including "DIABETES" as an additional independent variable, and made a comparison between the result of the model including "DIABETES" and the result of the model excluding "DIABETES". I can consider that the influence of the independent variables on the dependent variables is not as strong as that of "DIABETES", if signification of an independent variable changes by including "DIABETES".

Moreover, I added a year-dummy variable. This was to control factors which independent variables could not explain fully, such as revision of treatment fee. All variables had been transformed into logarithms.

First, I performed pooled ordinary least squares regression analysis. This was to estimate how independent variables predicted dependent variables.

Second, I performed panel analysis. This was to allow for individual effects of unobserved components. Individual effects mean prefectural specifications. In this panel analysis, I estimated a fixed effect model and a random effect model. In a fixed effect model, it is assumed that individual effects are correlated with independent variables. In a random effect model, it is assumed that individual effects are not correlated with independent variables. The panel analysis is done with panel data of cross-sectional time series. The panel data consists of observations on i analytical units and repeated over t points in time. In this paper, i was 47 units and t was 2 points in 1999 and 2002.

Finally, F test and Hausman test were done. F test was done to choose the optimal model between the pooled ordinary least squares regression model and the fixed effect model. Hausman test was done to choose the optimal model between the random effect model and the fixed effect model.

Furthermore, the White test was done to check the hypothesis of homoscedasticity.

RESULTS

Descriptive statistics of the data before logarithmic transformation were shown in Table 1.

Figure 1

Table 1: Descriptive statistics (n=94)

Variables	Mean	Standard deviation	Minimum	Maximum
PERIO (persons)	172.95	58.03	83.00	380.00
PERIO70 (persons)	174.15	134.91	3.00	1061.00
TOOTHBRUSH (yen)	1290.25	230.76	784.74	2109.00
SMOKING (%)	14.82	3.07	7.98	24.30
DIABETES (%)	9.20	2.68	0.85	19.53
EDUCATION (persons)	507.96	320.13	26.08	1663.89
CHECKUP (persons)	5352.35	4672.39	38.02	24508.09
INCOME (thousand yen)	2765.99	368.93	2031.00	4351.00
CHAIR (the number of chairs)	149.02	19.40	112.03	227.71
DENSITY (persons/km^2)	1396.35	1643.04	243.52	9109.82
POPULATION40 (%)	53.55	3.11	44.13	60.54
POPULATION50 (%)	40.25	3.27	29.19	47.16
POPULATION60 (%)	25.58	3.17	17.95	32.23
POPULATION70 (%)	13.52	2.48	7.63	19.29
POPULATION80 (%)	4.49	0.94	2.37	7.00

The maximum of “PERIO70” as a dependent variable was about 350 times as large as the minimum. The maximum of “DIABETES” as an independent variable was about 20 times as large as the minimum. The maximums of “SMOKING” and “TOOTHBRUSH” as variables about lifestyle were about 3 times as large as the minimum.

As a result of F and Hausman tests, the fixed effect model was adopted and the necessity of accounting for the fixed effect was ascertained. The results were shown in Tables 2, 3, and 4. In addition, the hypothesis of homoscedasticity was rejected as a result of the White test. Therefore, we estimated with White heteroscedasticity-consistent standard errors.

Figure 2

Table 2: Regression results (not including DIABETES)

	Fixed Effect Model			
	(a)	(b)	(c)	(d)
Dependent Variable	PERIO			
Independent Variables				
Year Dummy	0.16494 **	0.29058 **	0.08234 **	-0.24314 **
TOOTHBRUSH	-0.14399 **	-0.25304 **	-0.14047 **	-0.09804 **
SMOKING	0.83847 **	0.85462 **	0.73101 **	0.59663 **
DIABETES				
EDUCATION	-0.22023 **	-0.19816 **	-0.20982 **	-0.11950 **
CHECKUP	-0.06720 *	-0.07210 **	-0.07066 **	-0.01210
INCOME	-0.29984	-1.06851 **	0.04926	0.04046
CHAIR	-1.85577 **	-2.33280 **	-1.08932 **	-0.50825 *
DENSITY	-4.34486 **	-4.89783 **	-5.23345 **	-5.72987 **
POPULATION40	-3.59980			
POPULATION50		-6.16230 **		
POPULATION60			0.93155	
POPULATION70				6.27242 **
Adjusted R^2	0.999635	0.999837	0.999749	0.999932
Number of samples	94	94	94	94

$p< 0.01$; **, $p< 0.05$; *

Fixed Effect model (a) ; Included POPULATION40 as an independent variable about population rate.

Fixed Effect model (b) ; Included POPULATION50 as an independent variable about population rate.

Fixed Effect model (c) ; Included POPULATION60 as an independent variable about population rate.

Fixed Effect model (d) ; Included POPULATION70 as an independent variable about population rate.

Figure 3

Table 3: Regression results (including DIABETES)

	Fixed Effect Model			
	(e)	(f)	(g)	(h)
Dependent Variable	PERIO			
Independent Variables				
Year Dummy	0.16888 **	0.23190 **	0.09118 **	-0.20998 **
TOOTHBRUSH	0.09391	-0.03941	0.02245	-0.01536
SMOKING	0.82044 **	0.84006 **	0.75074 **	0.57990 **
DIABETES	0.13604 **	0.12253 **	0.12148 **	0.16901 **
EDUCATION	-0.16475 **	-0.16024 **	-0.18218 **	-0.08641 **
CHECKUP	-0.08476 **	-0.06463 *	-0.06449 **	-0.02970 *
INCOME	-0.97698 **	-1.31955 **	-0.07470	0.26726
CHAIR	-1.79961 **	-2.01386 **	-1.43401 **	-0.64190 **
DENSITY	-3.35163 **	-2.90873 **	-4.53877 **	-4.35139 **
POPULATION40	-5.94509 *			
POPULATION50		-4.74949 **		
POPULATION60			0.43946	
POPULATION70				5.70957 **
Adjusted R^2	0.999925	0.999464	0.999998	0.999733
Number of samples	94	94	94	94

$p< 0.01$; **, $p< 0.05$; *

Fixed Effect model (e) ; Included POPULATION40 as an independent variable about population rate.

Fixed Effect model (f) ; Included POPULATION50 as an independent variable about population rate.

Fixed Effect model (g) ; Included POPULATION60 as an independent variable about population rate.

Fixed Effect model (h) ; Included POPULATION70 as an independent variable about population rate.

Figure 4

Table 4: Regression results (Elderly people)

	Fixed Effect Model	
	(i)	(j)
Dependent Variable	PERIO70	
Independent Variables		
Year Dummy	0.91269 **	0.56510 **
TOOTHBRUSH	-0.61278 **	-0.06860
SMOKING	0.02855	0.01998
DIABETES		0.90264 **
EDUCATION	-0.80508 **	-0.69843 **
CHECKUP	0.00349	-0.02544
INCOME	1.47379 **	2.53417 **
CHAIR	-0.58962	-3.01758 **
DENSITY	-13.59501 **	-2.75371
POPULATION80	-10.86469 **	-5.18097 **
Adjusted R^2	0.999968	0.998715
Number of samples	94	94

$p< 0.01$; **, $p< 0.05$; *

Fixed Effect model (i) ; Not included DIABETES as an independent variable.

Fixed Effect model (j) ; Included DIABETES as an independent variable.

In tables, plus signs of coefficients mean the independent variables have the positive influence on the dependent variables. Minus signs of coefficients mean the independent variables have the negative influence on the dependent variables. Values of coefficients mean elasticity. That is to say, it means how percent the dependent variables change on 1 percent change of the independent variables.

I showed the results of the estimations excluding "DIABETES" as an independent variable in Table 2. In (a), (b), (c), and (d), "TOOTHBRUSH" showed a significant negative correlation with "PERIO". "SMOKING" showed a significant positive correlation with "PERIO". "EDUCATION" and "CHAIR" showed significant negative correlations with "PERIO". In (a), (b), and (c), "CHECKUP" showed a significant negative correlation with "PERIO". In (b), "POPULATION50" showed a significant negative correlation with "PERIO". In (d), "POPULATION70" showed a significant positive correlation with "PERIO".

I showed the results of the estimations including "DIABETES" as an independent variable in Table 3. In (e), (f), (g), and (h), "SMOKING" and "DIABETES" showed a significant positive correlation with "PERIO". "EDUCATION", "CHECKUP", and "CHAIR" showed significant negative correlations with "PERIO". In (f), "POPULATION50" showed a significant negative correlation with "PERIO". In (h), "POPULATION70" showed a significant positive correlation with "PERIO". In (e) and (f), "INCOME" showed a significant negative correlation with "PERIO".

I showed the results of the estimation excluding "DIABETES" as an independent variable in Table 4. In (i), "TOOTHBRUSH" showed a significant negative correlation with "PERIO70". "EDUCATION" and "POPULATION80" showed a significant negative correlation with "PERIO70". In (i) and (j), "INCOME" showed a significant positive correlation with "PERIO70".

I showed the results of estimation including "DIABETES" as an independent variable in Table 4. In (j), "DIABETES" showed a significant positive correlation with "PERIO70". "EDUCATION", "CHAIR", and "POPULATION80" showed a significant negative correlation with "PERIO70".

DISCUSSION

To keep the good financial condition of health insurance in the dental field, it is very important to analyze the relationship between the consultation rate for periodontal disease and lifestyle. If improvement of lifestyle leads to decrease the consultation rate, I can decrease medical expenses for dental care, because the consultation rate has an influence on national finance directly.

I considered the consultation rate was more suitable than the disease rate in this study. Because periodontal disease is chronic, there are few subjective symptoms, and the disease rate is not always connected with medical expenses for dental care. Therefore, the consultation rate is more important and suitable index from a financial viewpoint of public health insurance.

Generally, in analyzing medical expenses or the consultation rate, it is necessary to take into consideration factors of population dynamics such as urbanization, the percentage of elderly people, factors of inflation with respect to income and the cost of medical services, and factors of natural growth such as medical technology. In this study, I analyzed on the basis of stylized facts.

Since the populations and areas were different by prefecture, the difference was adjusted by the population density. Thus, "DENSITY" was included as a variable in all estimation models.

I used various independent variables about population rate. And one of these variables was included in the estimation models to control the difference of population composition by prefecture, and to check the age to have an influence on the dependent variable. From the result in Table 2 and 3, the consultation rate decreases by the increase of the rate of people over 50 years old, or by the decrease of the rate of people over 70 years old. As the rate of people over 70 years old is higher, the consultation rate of people is higher. From the result about "POPULATION50", I can consider the rate of people who consult a doctor for another dental disease is higher in 50's and 60's. It is difficult to interpret the result about "POPULATION80" in Table 4. But this variable plays a role to control the difference of population composition by prefecture.

Strictly speaking, "TOOTHBRUSH" does not show how much quantity of plaque, which is the main cause of gingivitis or periodontal disease, has been removed. However, I assumed that people spending a lot of money on toothbrushes brushed their teeth eagerly, adopted "TOOTHBRUSH" as a substitute variable for lifestyle. Although I also had an idea to use the annual amount spent on toothpaste per household as a variable, I did not adopt this as a variable. Because there were a variety of toothpastes and the difficulty of interpretation of the result. In the future, to analyze the relationship between medical expenses for dental care and brushing skill and to analyze the relationship between the consciousness about dental health and frequency of changing toothbrushes are expected.

I had a hypothesis that the coefficient for "TOOTHBRUSH" would be negative. Namely the hypothesis was that the consultation rate would decrease with the increase of the annual amount spent on toothbrushes per household. In this study, "TOOTHBRUSH" showed a significant negative correlation in the model excluding "DIABETES". But "TOOTHBRUSH" did not show a significant correlation in the model including "DIABETES". I can consider the following from this result. Though improving sanitary conditions in the mouth by brushing teeth decreases the consultation rate and medical expenses for dental care, its effect is not as strong as that of prevention of diabetes. Oral hygiene indices or plaque indices are more suitable variables about removal of plaque. So, collection of these data is expected from now on.

Smoking is a bad lifestyle on health, and it is a hot issue. There are some researches about the relationship between smoking and periodontal disease from a medical viewpoint. For example, tobacco increased the severity of periodontal disease and this effect was clinically evident above a certain level of tobacco consumption[1]. A strong association between smoking and both attachment loss and recession in subjects who had minimal or no periodontal disease was shown[3]. In addition, a lot of researches[3,4,5,6,7] have shown the relationship between smoking and periodontal disease. Some researches[8] has been done specifically on Japanese people. As there are few researches that periodontal disease has the relationship with smoking from an economical viewpoint, however, this study is very significant.

The data of smoking rate for the analysis are based on the data in 2000 and 2003. While the data of smoking rate in 2000 is based on the number of people smoking 0 cigarettes or more a day, the data in 2003 is based on the number of people smoking 20 cigarettes or more a day. I have to notice the difference of definition about smoking rate between in 2000 and in 2003. However, I considered it did not have an influence on the result.

I had a hypothesis that the coefficient for "SMOKING" would be positive. Namely the hypothesis was that the consultation rate would increase with the increase of the smoking rate. The results in Table 2 and 3 were consistent with the hypothesis. The consultation rate does not rise immediately even if people have a heavy smoking habit. The results suggested the existence of many potential patients, and a health policy for non-smoking lifestyle was very important from a viewpoint of medical expenses for dental care. About elderly people, it is considered that the factors except smoking rate have an influence on the consultation rate strongly.

From the result about "EDUCATION" in Tables 2, 3, and 4, I can consider that health education decreases the consultation rate and controls medical expenses for dental care.

From the result about "CHECKUP" in Table 2, 3, and 4, I can consider that the checkup has an effectiveness for prevention of periodontal disease except elderly people.

From the result about "INCOME" in Table 2 and 3, its influence for the consultation rate of people for all ages was not clear. From the result about "INCOME" in Table 4, income increased the consultation rate of people over 70 years old. Generally speaking, elderly people have much

interest in health. Richer elderly people may consult a dentist more frequently.

The number of medical institutions or hospital beds is generally used as a variable showing accessibility to medical treatment. Considering that the rate of outpatients was too high in dentistry[d] and that dental chairs were usually indispensable for dental treatment, however, I adopted the number of dental chairs as a variable.

I have to pay attention to the result that "CHAIR" showed a significant negative correlation with the consultation rate. Namely the result showed that the consultation rate decreased with the increase of the number of chairs. Supplier-induced demand in dentistry in Japan was rejected[14]. I can make some following hypotheses from the result. In areas where competition among dental clinics is keen, there may be few patients who have periodontal disease, because clinical policies regard the prevention of dental disease as important, or because people may be able to prevent periodontal disease by themselves. As these ideas are simply speculations at present, I expect a lot of researches to clarify these.

I are also very interested in the results of the fixed effect model that "DIABETES" was added as an independent variable in Tables 3 and 5. I had a hypothesis that the coefficient for "DIABETES" would be positive. Namely the hypothesis was that the consultation rate would increase with the increase of diabetics. This hypothesis was consistent with the results. From a medical viewpoint, the relationship between diabetes and periodontal disease were reported[9,10,11,12]. They reported that diabetes exacerbated periodontal disease. The results showed that diabetes also influenced the consultation rate for periodontal disease. This means that health policy for diabetes is important in controlling medical expenses for dental care. For example, the prevention of obesity which is one of the causes of diabetes is also very important from the economical viewpoint in the dental field.

In the future, more studies about the relationship between medical expenses for dental care and lifestyle by using micro data can be expected.

GLOSSARY

[a] Statistics Bureau, Ministry of Internal Affairs and Communications, (1999) Social Indicators by Prefecture 1999, Japan Statistical Association, Tokyo.

[b] Statistics Bureau, Ministry of Internal Affairs and Communications, (2002) Social Indicators by Prefecture 2002, Japan Statistical Association, Tokyo.

[c] Statistics Bureau, Ministry of Internal Affairs and Communications, (2003) Annual Report on the Consumer Price Index 2003, Japan Statistical Association, Tokyo.

[d] Ministry of Health, Labour and Welfare, (2004) Patient Survey 2002, Health and Welfare Statistics Association, Tokyo.

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