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Income or education, which has a stronger association with dental implant use in elderly people in Japan?

Running title: Social inequalities in implant use.

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Abstract

Objective Although social inequalities in dental implant use have been reported, no study has used income variables to measure such inequalities before. Whether income or education has a stronger association with inequalities in dental implant use is unknown. We examined whether income or education has a stronger association with inequalities in dental implant use in older Japanese.

Methods In 2016, a self-reported questionnaire was mailed to participants aged 65 years or older living across Japan as part of the ongoing Japan Gerontological Evaluation Study. We used data from 84,718 respondents having 19 or fewer teeth. After multiple imputation, multi-level logistic regression analysis estimated the association of dental implant use with equivalised income level and years of formal education. Confounders were age, sex, and density of dental clinics in the residential area.

Results 3.1% of respondents had dental implants. Percentages of dental implant use among the lowest (≤9years) and highest (≥13years) educational groups were 1.8 and 5.1, respectively, and among the lowest (0<12.2 “1000USD/year”) and highest (≥59.4 “1000USD/year”) income groups were 1.7 and 10.4, respectively. A fully adjusted model revealed both equivalised income level and years of formal education were independently associated with dental implant use, with stronger association observed between income and dental implant use. Odds ratios for implant use in the highest education group and the highest income group were 2.13 [95%CI=1.94-2.35] and 4.85 [95%CI=3.78-6.22] compared to the lowest education and income groups respectively.

Conclusion These results suggest that even those with the highest education level but with low income might have limited accessibility to dental implant services.

Keywords dental implant(s), access to care, dental services research, dental public health, epidemiology.

Introduction

Although a rise in the demand and use of dental implant treatment services has been reported in Sweden and the United States (US)[1,2] the higher treatment cost associated with these services is likely to cause strong income inequalities. The treatment costs of dental implants are higher than those of conventional treatments, such as endodontic treatment and complete and partial denture treatments[3,4]. The average cost of a single tooth implant in Japan ranges from “3000 to 6000 USD”, with annual maintenance fees ranging from “30 to 100 USD”, depending on where treatment takes place[5]. Social inequalities in dental implant use have been previously reported in a few studies from the United States (US)[2,6,7]. However, these studies could not measure income inequality in dental implant use. Two studies used geographical location (zip code) as a proxy for socioeconomic status (SES)[6,7], and one study used educational attainment as an indicator of SES[2]. Because income is considered to be directly related to the payment for implant treatment, inequalities in income should be directly measured.

Educational attainment has also been used as an index of SES. Education affects health through not only employment position and income but also knowledge, health-promoting decisions, literacy, and obtaining a well-educated social network[8]. Because dental implants have several merits related to function, quality of life and patient satisfaction compared with conventional treatments[9,10], highly educated patients may prefer dental implants. However, it is still possible that even patients with high education but with low income levels could be restricted from accessing dental implant treatment. Studies examining the effects of both individual education and income variables on dental implant use are required.

Japan is ranked the top country with the lowest out-of-pocket dental expenditure because the public insurance system widely covers dental care[11], and it is also ranked as the top country with the highest access to dental care, with 3.2 times dental visits per person per year in 2015[12]. Additionally, Japan has adopted a universal health care insurance system for the general population since 1961[13], through which beneficiaries can access medical and dental treatment when needed and only pay 10% to 30% of the total costs of treatment depending on income, age and health condition[14]. Nevertheless, dental implant therapy is not covered by insurance except in rare cases of absolute necessity, such as those involving congenital, pathological and accidental jaw bone deficiencies[15]. In Japan, any licensed dentist is allowed to practise dental implant treatment, and it is the dentist's decision whether to refer patients to a dental implant specialist[14]. Because conventional care is covered by universal health care insurance, while implant care is not, implant care may be selected only by affluent people who can afford to pay for it out of their own pockets, even if implants are the best treatment option. Additionally, patients may choose the covered conventional care over the un-covered implant care when they have the choice and consequently inequalities in dental implant use may be greater in Japan than in other countries.

The aim of this study was to examine the association between dental implant use and two predictors of SES (equivalised income level and years of formal education) among older Japanese populations and to examine whether income or education has a stronger association with dental implant use. We hypothesized that 1) social inequalities in dental implant use exist in Japan and 2) social inequalities in dental implant use are more strongly associated with income level than with education level.

Methods

In our cross-sectional study, we used data from the Japan Gerontological Evaluation Study (JAGES), an ongoing prospective cohort study concerned with the cognitive function, social, and health status of the older Japanese population[16]. In 2016, the JAGES survey was conducted in 38 municipalities in 18 different prefectures (out of 47 prefectures) across Japan for a community-dwelling population aged 65 years or older. A simple random sampling was conducted in 22 large municipalities, and a survey for all 65 years or older residents was conducted in 16 smaller municipalities. A self-reported questionnaire containing a question related to dental implants was sent by mail to 279,661 functionally independent target participants. In the questionnaire, we asked about the number of remaining teeth as follows: “How many natural teeth do you presently have?”, with five potential answers, “I have no natural teeth”, “I have 1 to 4 natural teeth”, “I have 5 to 9 natural teeth”, “I have 10 to 19 natural teeth”, or “I have 20 or more natural teeth”. We followed STROBE guidelines for cross-sectional studies.

Outcome variable

Our outcome variable was having dental implants or not. In our questionnaire, we asked “Do you have any dental implants in your mouth?”, and the participants chose “Yes” or “No”.

Predictors

The two predictors for SES were equivalised income level and years of formal education. Questions related to annual income, number of people in the household, and years of formal education were included in the JAGES project questionnaire. We calculated equivalised income level as the annual pre-tax household income divided by the squared root of the number of people in the household. According to the Japanese comprehensive survey of living conditions, the relative poverty level, which refers to income less than half of the median annual income, was 12,200 USD in 2013[17]. We used this threshold to categorize our lowest income level group. Following a previous study[18], we applied other income categories as shown in (Tables 1, 2, and 3). We used the currency exchange rate of (100 JPY=1 USD) to convert our equivalised income level results to USD. For years of formal education, we asked "How many years of formal education do you have?", with four categorical answers: "<6, 6-9, 10-12, >=13 years". We grouped the first two categories together because the number of respondents with <6 years of formal education who used dental implants was small (n=5).

Confounders

Age and sex were included as demographic characteristics. The number of dental clinics in residential areas was considered a proxy for geographical accessibility to dental care, including dental implant treatment. Because geographical accessibility to care and SES were correlated, it was considered a confounder. For each of the included 38 municipalities, we gathered the data on the number of dental clinics in the residential area and the corresponding population size from the 2014 survey of Physicians, Dentists and Pharmacists[19] to calculate the density of dental clinics per 10,000 residents.

Statistical methods and data analysis

We built 7 multi-level logistic regression models to calculate the odds ratio of dental implant use with both of our SES predictors. We initially ran 6 models for equivalised income level and years of formal education separately (3 models for each). The first and second models were unadjusted. The third and fourth models were adjusted for age and sex. The fifth and sixth models were adjusted for age, sex and number of dental clinics in residential areas. In a seventh and final fully adjusted model, we included both equivalised income level and years of formal education simultaneously. We conducted a Spearman correlation test to assess any collinearity between the two SES variables.

We applied a multiple imputation (MI) analysis to address missing data. We used 20 chained equation analyses. For sensitivity analysis, we applied complete case analysis (n= 58,232) after dropping all participants with any missing value on the outcome, predictors or confounders. All analyses were conducted using Stata/SE 14 software from StataCorp LP (College Station, Texas, USA).

Results

Of the 279,661 functionally independent participants to whom the questionnaire was mailed, 179,991 responded (response rate=64.3%). Only those who reported having 19 teeth or less (n=84,718) were included in the analysis, because the rest of respondents reported having 20 or more teeth (n=95,273) and that mean that they might have a complete dentition; consequently, we omitted this category of respondents. In our study population, 47.9% of the participants were males (n= 38,990), and 52.1% were females (n=42,318). The mean age was 75.70 (SD±6.65 years). Descriptive statistics are shown in (Table 1). Overall, 2,552 (3.1%) participants had dental implants. Higher dental implant use was observed in females and younger age groups. Spearman correlation showed that both SES variables were independent (Spearman's rho = 0.2187, P< 0.0001). In our analytical sample, 24,721 participants had missing data on equivalised income level, 1,884 had missing data on years of formal education, and 3,410 had missing data on having dental implants or not. All these data were imputed and included in the analyses, while we had complete data for age, sex and density of dental clinics in residential areas. A clear step-wise social gradient in dental implant use by both equivalised income level and years of formal education variables was observed (Figure 1), and the association between the equivalised income level and dental implant use appeared to be stronger than that between years of formal education and dental implant use. (Table 2) shows the results of the multi-level logistic regression analyses with multiple imputation. A clear step-wise social gradient was also observed in dental implant use in all our regression models consistently across all higher income or education groups. A steep increase in the odds ratios for dental implant use was observed among the respondents with the highest income (≥59.4 “1000 USD/year”) in all regression models. In our fully adjusted model (model 7), when we included both SES variables, the odds ratios of income appeared to be higher than that of education. Our sensitivity analysis performed using complete case analysis, after dropping all participants with missing values, revealed very similar results (Table 3).

Discussion

To the best of our knowledge, this is the first study to examine the association between income level and dental implant use. In addition, we compared the effect of the association of both income and education levels on implant use. Additionally, this is the first study to describe the prevalence and demography of dental implant use in Japan. Income level showed a stronger association with dental implant use than did education level. In addition, both education and income levels were independently associated with dental implant use. Our study suggests that even participants with the highest education level but without high income might have limited accessibility to dental implant treatment. This study also shows that there is a clear, step-wise social gradient in dental implant use favouring each successively higher SES group.

Study limitations

Self-reporting of whether patients had implants or not may have been flawed because of mis-classification of received treatment by respondents. However, our reported prevalence of dental implant use (3.1%) is similar to that indicated by the results of the survey on the actual condition of dental diseases conducted by the Japanese Ministry of Health, Labour and Welfare published in 2016 which was based on clinical examination[21], and reported a 3.6% prevalence of dental implant use for participants aged 65 years and older. Also, in our questionnaire, there were two other separate questions related to bridge and denture treatments. In addition, the number of dental implants per capita was not included in our questionnaire. Such information would have provided deeper insight concerning the quantity of dental implants for each participant and their association with socioeconomic status. Additionally, data on income and dental status are self-reported; therefore, the association between income and dental implant use might have been over- or under-estimated. However, self-reported data are reliable for oral epidemiological studies in Japan[20]. Due to the limitations of our questionnaire, the last category of participants who reported having 20 or more teeth were dropped from the analysis because some of them might have complete dentition. However, our sample size is still large, and the dropped category is unlikely to change the results significantly.

Strengths of this study

This is the first study to examine the association between income level and dental implant use. Additionally, it is the first study to include two socioeconomic predictors simultaneously in an analytical model to assess the stronger predictor of social inequalities in dental implant use. Additionally, our study is a community dwelling-based study for elder population with a large sample size; yet, not nationally representative sample. Most importantly, dental implant provision in Japan is an ideal service for assessing social inequalities in “out of insurance” dental health services utilization, as the universal health insurance system provides wider coverage for basic dental services but not dental implants. Finally, this is the first study to describe the precise pattern (step-wise social gradient) of social inequalities in dental implant use because previous studies have used only binary categories of SES (high and low), and therefore, they could not show the social gradient of dental implant use.

Our results are consistent with the results of three previous studies from the US. Those studies reported an increase in the odds ratio for dental implant use among the higher SES groups[2,6,7]. However, none of these studies examined the association of income level as a predictor of dental implant use. The current prevalence of dental implant use (3.1%) is similar to that indicated by the results of the survey on the actual condition of dental diseases conducted by the Japanese Ministry of Health, Labour and Welfare published in 2016 which was based on clinical examination, and reported a 3.6% prevalence of dental implant use for participants aged 65 years and older[21]. Additionally, the prevalence is similar to that reported in previous studies in other countries. For example, in a recent study from the US, the prevalence of dental implant use rose from 0.7% in 1999 to 2000 to 5.7% in 2015 to 2016[2]. In Switzerland, the prevalence of dental implant use in 2002 was 4.4%[22]. Additionally, in a comparative study, the prevalence of dental implants among Swedes was 4.8%, while it was 2.5% among Danes[23]. In a longitudinal study from Sweden, a rise in patient demand for dental implant therapy was significantly associated with higher income levels[24]. Most of these previous studies are relatively old, were concerned with the prevalence of dental implant use in a given population, and investigated the patient's need or the decision making of dental implant therapy rather than examining the association between dental implant use and SES.

With respect to public health implications, our study provides highly relevant information for policy and health care decision makers to better understand the determinants and extent of social inequalities in the utilization of health services that are not covered by insurance, especially in a system that provides universal health care for everyone, such as the Japanese system. To address these clear and extensive social inequalities in implant use and in alignment with the National Health Service (NHS) guidelines for implant use in UK[25], one option would be to include the dental implant service in the health insurance scheme but only for those who are most in need, such as the edentate who belong to low socioeconomic groups and have severe denture intolerance. In essence, the first line of treatment for the edentate would be the provision of conventional full dentures. In cases in which these dentures do not result in sufficient levels of oral function, implant-supported overdentures, which are associated with increased levels of satisfaction and quality of life[26,27], can be subsidized for low socioeconomic groups, while higher socioeconomic groups would be expected to cover the cost by themselves. In contrast to Japan, two European countries are adopting the reimbursement of dental implant costs. In the Netherlands, the health insurance system reimburses most costs of implant overdenture for edentulous patients with atrophic alveolar ridges, while in Sweden, equal reimbursement for removable and fixed implant prostheses exists, with a predominance of fixed implant supported prostheses over removable implant supported prostheses[28]. Additionally, in Korea, the health insurance system reimburses costs for 2 implants throughout the patient's lifetime for those aged 65 years and older[29].

Future studies are needed to assess the trends of dental implant use in Japan over time, preferably including data from younger age groups from a nationally representative sample including number of dental implants per capita, and site of implant placement. Wealth inequalities in dental implant use should be considered as an explanatory variable of similar results in future studies as it opens the debate on social class inequalities. Additionally, studies are needed to assess the causality between income, education and dental implant use. Additionally, surveys are needed to assess the actual workforce of dental practitioners who perform dental implant treatments to better estimate the association between dental implant use and the number of dental implant treatment providers. Finally, comparative analysis studies from different countries with different health care systems can help explain the global trends in dental implant use.

Conclusion

A stronger association was observed between equivalised income level and dental implant use. However, both equivalised income level and years of formal education were independently associated with dental implant use. Our study suggests that even participants with the highest education level but without high income might have limited accessibility to dental implant services. Also, a clear step-wise social gradient in dental implant use by both equivalised income level and years of formal education variables was observed. Collectively, our study results show that severe social inequalities in access to dental implant services exists in elder Japanese population. Relevant dental health policies are needed to address these social inequalities.

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Author contributions

Hazem Abbas contributed to the conception of the study, study design, data acquisition, analysis, interpretation and drafted the manuscript; Jun Aida contributed to the conception, design, data acquisition, analysis and interpretation; Masashige Saito contributed to the data analysis; Georgios Tsakos, Richard G Watt and Shigeto Koyama contributed to the data interpretation; and Katsunori Kondo and Ken Osaka contributed to the data acquisition. All authors critically revised the manuscript, gave final approval and agree to be accountable for all aspects of the work ensuring integrity and accuracy.

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Table 1. Descriptive distribution of dental implant use

Variable name	Dental implant use **N (%)**		**Total N (%)**
	No	**Yes**	
Sex			
Male	37,978 (97.4)	1,012 (2.6)	38,990 (47.9)
Female	40,778 (96.3)	1,540 (3.6)	42,318 (52)
Age group (years)			
65-69	17,302 (95.4)	830 (4.5)	18,132 (22.3)
70-74	19,030 (96.3)	732 (3.7)	19,762 (24.3)
75-79	19,144 (97)	587 (2.9)	19,731 (24.2)
80-84	14,483 (98)	296 (2)	14,779 (18.1)
85-max	8,797 (98.8)	107 (1.2)	8,904 (10.9)
Formal education (years)			
≤9	32,443 (98.1)	597 (1.8)	33,040 (41.5)
10-12	29,240 (96.4)	1,078 (3.5)	30,318 (38)
≥13	15,423 (94.8)	839 (5.1)	16,262 (20.4)
Equivalised income level groups (1000 USD/year)			
0<12.2	12,426 (98.2)	222 (1.7)	12,648 (20.7)
12.2≤29.7	34,108 (97)	1,046 (2.9)	35,154 (57.7)
29.7≤59.4	10,647 (94.6)	605 (5.3)	11,252 (18.4)
≥59.4	1,614 (89.5)	188 (10.4)	1,802 (2.9)
Density of dental clinics /10000 individuals			
<3	4,258 (97)	130 (2.9)	4,388 (5.4)
3<4	11,389 (97.5)	287 (2.4)	11,676 (14.3)
4<5	27,215 (97.3)	734 (2.6)	27,949 (34.3)
5<6	15,155 (96.1)	613 (3.8)	15,768 (19.3)
=>6	20,739 (96.3)	788 (3.6)	21,527 (26.4)

Abbreviations: n: number of participants.

Table 2. Odds ratios of equivalised income level, years of formal education, and confounders for dental implant use by multi-level logistic regression models with multiple imputation (N=84,718)

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)	Model 5 OR (95% CI)	Model 6 OR (95% CI)	Model 7 OR (95% CI)
Years of formal education							
≤9	1			1	1		1
10~12	1.92 (1.75-2.10)			1.76 (1.60-1.93)	1.75 (1.59-1.93)		1.54 (1.41-1.70)
≥13	2.73 (2.48-3.00)			2.64 (2.37-2.94)	2.63 (2.36-2.92)		2.13 (1.94-2.35)
Equivalised income level (1000 USD/year)							
0<12.2		1	1			1	1
12.2≤29.7		1.71 (1.52-1.92)	1.72 (1.53-1.94)			1.72 (1.54-1.94)	1.56 (1.39-1.76)
29.7≤59.4		3.17 (2.76-3.63)	3.15 (2.71-3.66)			3.15 (2.71-3.67)	2.66 (2.30-3.08)
≥59.4		6.00 (4.76-7.57)	6.00 (4.64-7.75)			5.99 (4.64-7.75)	4.85 (3.78-6.22)
Sex							
Male			1	1	1	1	1
Female			1.60 (1.46-1.74)	1.64 (1.50-1.78)	1.64 (1.50-1.78)	1.60 (1.46-1.74)	1.70 (1.55-1.86)
Age group (years)							
65-69			1	1	1	1	1
70-74			0.82 (0.72-0.92)	0.84 (0.74-0.95)	0.84 (0.74-0.95)	0.82 (0.72-0.92)	0.86 (0.76-0.97)
75-79			0.67 (0.58-0.77)	0.69 (0.60-0.79)	0.69 (0.60-0.79)	0.66 (0.58-0.77)	0.72 (0.63-0.83)
80-84			0.45 (0.39-0.53)	0.48 (0.41-0.56)	0.48 (0.41-0.56)	0.45 (0.39-0.53)	0.50 (0.43-0.58)
85-max			0.27 (0.21-0.35)	0.31 (0.24-0.40)	0.30 (0.23-0.40)	0.27 (0.21-0.35)	0.31 (0.24-0.40)
Density of dental clinics /10000 individuals							
<3					0.72 (0.39-1.34)	0.69 (0.37-1.28)	0.74 (0.40-1.36)
3<4					0.74 (0.54-1.02)	0.68 (0.47-0.97)	0.73 (0.53-1.00)
4<5					0.85 (0.62-1.15)	0.80 (0.57-1.12)	0.84 (0.61-1.14)
5<6					1.08 (0.80-1.44)	1.06 (0.75-1.49)	1.05 (0.78-1.41)
=>6					1	1	1
Variance at municipality level	0.11 (0.06-0.18)	0.12 (0.77-0.20)	0.11 (0.07-0.19)	0.11 (0.06-0.18)	0.09 (0.05-0.16)	0.09 (0.05-0.15)	0.08 (0.04-0.14)

All P-values were <0.001 except for the "density of dental clinics" variable.

Abbreviations: OR: odds ratio, CI: confidence interval

Model 1,2: Unadjusted.

Model 3,4: Age and sex adjusted.

Model 5,6: Age, sex and density of dental clinics adjusted.

Model 7: All confounders, years of formal education and equivalised income level adjusted.

Table 3. Results of the sensitivity analysis (complete case analysis): odds ratios of equivalised income level, years of formal education, and confounders for dental implant use by multi-level logistic regression models (N=58,232)

	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)	Model 4 OR (95% CI)	Model 5 OR (95% CI)	Model 6 OR (95% CI)	Model 7 OR (95% CI)
Years of formal education							
≤9	1			1	1		1
10~12	1.92 (1.71-2.15)			1.75 (1.56-1.96)	1.73 (1.54-1.94)		1.54 (1.38-1.72)
≥13	2.82 (2.50-3.17)			2.76 (2.43-3.14)	2.71 (2.37-3.09)		2.22 (1.96-2.50)
Equivalised income level (1000USD/year)							
0<12.2		1	1			1	1
12.2≤29.7		1.68 (1.50-1.89)	1.71 (1.53-1.92)			1.71 (1.52-1.92)	1.55 (1.38-1.72)
29.7≤59.4		3.14 (2.77-3.56)	3.18 (2.76-3.66)			3.17 (2.73-3.68)	2.69 (2.34-3.10)
≥59.4		6.03 (4.87-7.46)	6.17 (4.82-7.89)			6.11 (4.74-7.88)	4.92 (3.87-6.26)
Sex							
Male			1	1	1	1	1
Female			1.64 (1.46-1.83)	1.71 (1.53-1.90)	1.71 (1.53-1.90)	1.64 (1.47-1.83)	1.76 (1.57-1.97)
Age group (years)							
65-69			1	1	1	1	1
70-74			0.78 (0.69-0.89)	0.81 (0.70-0.92)	0.80 (0.70-0.92)	0.78 (0.68-0.89)	0.82 (0.72-0.94)
75-79			0.70 (0.60-0.81)	0.72 (0.62-0.84)	0.71 (0.61-0.84)	0.69 (0.59-0.81)	0.75 (0.64-0.88)
80-84			0.44 (0.36-0.53)	0.47 (0.38-0.58)	0.47 (0.38-0.58)	0.43 (0.35-0.53)	0.48 (0.39-0.59)
85-max			0.25 (0.18-0.34)	0.29 (0.20-0.40)	0.28 (0.20-0.41)	0.25 (0.17-0.35)	0.28 (0.20-0.40)
Density of dental clinics /10000 individuals							
<3					0.66 (0.35-1.24)	0.62 (0.32-1.20)	0.69 (0.36-1.31)
3<4					0.65 (0.48-0.87)	0.59 (0.41-0.84)	0.65 (0.47-0.90)
4<5					0.75 (0.55-1.01)	0.70 (0.49-1.00)	0.75 (0.54-1.05)
5<6					1.03 (0.81-1.31)	1.01 (0.74-1.37)	0.98 (0.74-1.30)
=>6					1	1	1
Variance at municipality level	0.13 (0.05-0.36)	0.17 (0.04-0.64)	0.17 (0.05-0.56)	0.14 (0.57-0.35)	0.09 (0.05-0.17)	0.09 (0.04-0.17)	0.08 (0.04-0.15)

All P-values were <0.001 except for the “density of dental clinics” variable.

Abbreviations: OR: odds ratio, CI: confidence interval

Model 1,2: Unadjusted.

Model 3,4: Age and sex adjusted.

Model 5,6: Age, sex and density of dental clinics adjusted.

Model 7: All confounders, years of formal education and equivalised income level adjusted.