博士論文

Individual- and Community-level Social Gradients of Edentulousness

無歯顎者に対する個人及び地域レベルの社会格差について

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Individual- and Community-level Social Gradients of Edentulousness

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Abstract

Community- level factors as well as individual-level factors affect individual health. No studies to date have examined the association between community-level social gradient and edentulousness. The aim of this study was to investigate individual- and community-level social inequalities in edentulousness and to determine any explaining factors in this association. We analyzed the data from the Japan Gerontological Evaluation (JAGES) Study. In 2010–2012, 112,123 subjects with aged 65 or older responded to the questionnaire survey (response rate = 66.3%). Multilevel logistic regression analysis were applied to determine the association between community-level income and edentulousness after accounting for individual-level income and demographic covariates. Then, we estimated the probability of edentulousness by individual- and community- level incomes after adjusted for covariates. Among 79,563 valid participants, the prevalence of edentulousness among 39,550 men (49.7%) and 40,013 women (50.3%) were both 13.8%. Living in communities with higher mean incomes and having higher individual-level income were significantly associated with a lower risk of edentulousness (odds ratios [ORs] by 10,000 USD increments were 0.37 (95% Confidential interval (CI) [0.22-0.63]) for community-level and 0.85 (95%CI

[0.84-0.86]) for individual-level income). Individual- and community-level social factors, including density of dental clinic, partially explained the social gradients. However, in the fully adjusted model, both community- and individual-level social gradients of edentulousness remained significant (ORs = 0.43 (95%CI [0.27-0.67]) and 0.90 (95%CI [0.88-0.91]) respectively). One standard deviation changes in community- and individual-level income were associated with respectively 0.78 and 0.84 times lower odds of edentulousness. In addition, compared to men, women living in communities with higher average incomes had a significantly lower risk of edentulousness (p-value for interaction<0.001). Individual- and community-level social inequalities in dental health were observed. Public health policies should account for social determinants of oral health toward reducing oral health inequalities.

Key words: oral health inequalities, community-level income, gender difference, edentulousness, multilevel analysis, (tooth loss)

Introduction

Severe tooth loss is the 36th most prevalent condition among 291 diseases and its caused loss of 106 disability-adjusted life-years per 100,000 population [1]. Prevalence of sever tooth loss was increasing according to age. Among older population, approximately 20% of them experienced sever tooth loss [2]. Severe tooth loss causes chewing difficulties and poor nutritional status [3]. It also affects general health status. For example, tooth loss predicts onset of future co-morbidities, such as dementia [4] and mortality [5].

Recent studies showed that prevalence of sever tooth loss was differed by socioeconomic groups [6-8]. These health inequalities are caused by social determinants of health and can be observed on social gradients [9]. Adverse social conditions such as lower income and lower educational attainment affect the health of not only the most disadvantaged people, but also the entire population within a society. The differences in social conditions create a stepwise gradient of health conditions between social groups. The total loss of teeth (i.e., edentulousness) reflects the social determinants of an individual's life-course, as it is the result of oral health behavior, oral diseases, and the community health care system. Reducing oral health inequalities is an urgent matter

for both researchers and policy-makers [10-12]. Furthermore, determining the factors that affect oral health inequalities is important for future public health intervention.

Recent studies have demonstrated that not only individual factors, but also community-level social determinants such as income inequalities or community-level mean income affect the health of individuals and facilitate health inequalities [7, 8, 13]. Because community factors potentially affect the health of all residents in the areas, it is important to understand their effects on health. However, to the best of our knowledge, no study has examined the both individual- and community-level social gradients of edentulousness. The aims of the present study were 1) to investigate the association between individual- and community-level incomes and edentulousness, 2) to determine the explaining factors on edentulousness inequalities, and 3) to investigate gender differences within the socioeconomic inequalities of edentulousness.

Methods

Data collection

We used cross-sectional data from the Japan Gerontological Evaluation Study (JAGES) cohort study in Japan. The JAGES project is an ongoing prospective cohort study investigating social and behavioral factors associated with the loss of health related to functional decline or cognitive impairment among individuals aged 65 years or older [6, 14]. Between August 2010 and January 2012, a total of 169,215 community-dwelling people aged 65 years and older were randomly selected from 31 municipalities in 12 prefectures in Japan and mailed a set of questionnaires. In total, 112,123 people in 31 municipalities participated (response rate = 66.3%). We used data from 79,563 participants without missing responses.

Outcome variable

The outcome variable for the present analysis was edentulousness (i.e., edentulous or dentulous). Current dental status was measured by a self-administered questionnaire. Respondents were asked "What is the status of your dental health?" with four choices:

1) I have 20 or more natural teeth, 2) I have 10 to 19 natural teeth, 3) I have 1 to 9 natural teeth, or 4) I have no natural teeth. We categorized answers 1–3 as "dentulous" and answer 4 as "edentulous."

Main predictors

We used two income variables as the main predictors. The individual-level equivalent household income was obtained and calculated from the questionnaire. The community-level mean income was obtained from national census data. Both income variables were used as a continuous variable and the unit used was 10,000 USD (1 USD = 100 JPY).

Individual-level socio-demographic covariates

Sex, age (65–69, 70–74, 75–79, 80–84 and >84 years old), marital status (currently married, widowed, divorced, never married, and others), and education (years of received school education: <6, 6–9, 10–12, >12 years, and others) were used as individual-level socio-demographic covariates.

Community-level socio-demographic covariates

As the proxy of access to dental care in communities, density of dental clinic in each municipality in 2010 were obtained from the census data and used as community-level variable [15, 16].

Data analysis

In our dataset, 79,563 individuals (individual-level) were nested across 30 municipalities (community-level). We have hypothesized that oral health is affected not only by individual-level socioeconomic status but also by community-level social conditions. To examine the contextual effect of community-level income on edentulousness, we applied a 2-level multilevel logistic regression analysis with random intercepts and fixed slopes. To determine explaining factors in the association between individual- and community-level income and edentulousness, we built the models as follows. Model 1 tested the association between individual- and community-level income and edentulousness. Model 2 tested the association between income variables and

edentulousness after adjusting for age, sex, and marital status. Model 3 added education into Model 2. Model 4 was the fully adjusted model, adding community-level variables—density of dental clinic—into Model 3. To determine gender differences in the effect of both individual- and community-level income on dental health, interaction terms were included in the fully adjusted model. To evaluate the degrees of individual- and community-level variance in edentulousness, median odds ratios were calculated [17]. To compare the degrees of the association between individual- and community-level income variables and edentulousness, we constructed a fully adjusted model with standardized income variables. When non-standardized income variables were included into the models, they were grand mean centered. Analysis were conducted using MLwiN version 2.28 (Centre for Multilevel Modelling, University of Bristol, UK).

Ethical considerations

Ethical approval for the study was obtained from the Ethics Committee at Nihon Fukushi University, Japan.

Results

The average ages of 39,550 men (49.7%) and 40,013 women (50.3%) were 73.5 (SD = 5.97) and 73.7 (SD = 6.17) years old respectively. The prevalence of edentulousness was 13.8% for both men and women. Table 1 shows the demographic distribution of the variables by dental status. Edentulous individuals significantly had lower income and lived in communities with lower mean incomes ($p < 0.001$).

Table 2 shows the results of the multivariate multilevel analysis. In the intercept-only model (not shown) there was a significant difference in edentulousness between municipalities (community-level variance: $\Omega_\gamma = 0.262$, SE = 0.069). The median odds ratio in the model was 1.629, which indicated that if a person moved to another municipality with a higher probability of poor dental status, their median risk of edentulousness would increase 1.629 times.

Having a 10,000 USD higher income and living in a community with a 10,000 USD higher mean income were associated with 0.85 times and 0.37 times lower risk for edentulousness respectively (Model 1). Individual characteristics mediated these relationships by 13.5% (individual-level income) and 3.4% (community-level income), respectively (Model 2, calculated from the odds ratios [ORs][18]). Education further

attenuated the ORs of individual- and community-level income variables by 20.5% and 3.8% respectively (Model 3). Community-level covariates, density of dental clinic mediated only the association between community-level income and edentulousness (2.1% reduction of the OR, Model 4). Even after considering all covariates, there remained significant geographical differences and individual- and community-level social gradients for edentulousness (Model 4). When standardized income variables were included in Model 4 instead of the non-standardized income variables, ORs for individual- and community-level income variables were 0.84 (95% confidential interval (CI) [0.82–0.87]) and 0.78 (95% CI [0.68–0.89]) respectively. There was a significant interaction between gender and community-level income, although the interaction between gender and individual-level income was non-significant (Models 5 and 6). Compared to men, women living in areas with higher community-level incomes had a lower probability of edentulousness (Figure). For individual-level income, a similar social gradient was observed among both men and women (Figure).

Discussion

To the best of our knowledge, this study was the first to examine both the individual- and community-level social gradients of edentulousness using multilevel analysis. A large-scale multilevel analysis demonstrated that not only income of individuals but also community-level income showed social gradients for edentulousness. Individual socioeconomic characteristics partially mediated the association between individual-level income and edentulousness. Socio-demographic characteristics of communities partially mediated the association between community-level income and edentulousness. However, even after adjusting for all covariates, individual- and community-level social gradients remained. In addition, compared to men, women living in municipalities with higher community-level incomes derived greater benefit from the social environment on oral health.

The present study reports results similar result to previous studies using non-oral health outcomes, which have suggested that community-level social factors affect population health. A systematic review and meta-analysis showed that community-level poor socioeconomic environment increased resident mortality. A meta-analysis of 11 studies with smaller sample sizes indicated that living in areas with

low socioeconomic status increased mortality 1.11 times compared to an area with high socioeconomic status. Another meta-analysis of seven studies with larger sample sizes also demonstrated that living in low socioeconomic status areas increased mortality 1.07 times [13]. In oral health studies, regardless of individual-level income, adults living in affluent areas had a higher number of remaining teeth than those living in deprived areas, after adjusting for age, sex, and education [8]. Dental health is considered to be affected to a greater extent by community-level factors. Previous studies conducted in one Japanese prefecture reported larger geographical differences in the dental outcome of number of remaining teeth compared to self-rated health [7]. Therefore, a public health intervention considering community-level social determinants would be more effective.

There are at least two possible pathways between community-level income and oral health. First, access to dental care could explain the mechanism. Although we considered access to dental clinic in the models, there might be unexplained variance of the outcome associated with access to dental care. A previous study demonstrated that low-income individuals had less access to dental clinic than high-income individuals [19]. Moreover, access to dental clinic was significantly associated with area-level income after adjusting individual income [20] . This study suggested that people living

in affluent areas were more likely to visit dental clinic than those in deprived areas, regardless of individual socioeconomic status. Although the variable we used, density of dental clinic, could change throughout life-course of each respondent, we could not consider the change of the variable. Therefore, this might be caused the unexplained variance of the outcome which associated with access to dental care. Second, individual health behaviors are formed by the surrounding environment. Compared to deprived communities, affluent communities tend to have positive social environments, including sufficient groceries with fresh and healthy food, public safety, and good access to hospital and dental clinic [21, 22]. People living in affluent communities tend to eat more fruits and sugar-free foods because they can easily purchase healthy foods at grocery stores in their communities [23, 24]. Healthy lifestyles can prevent dental caries, as sugar is one of the major risks for dental caries. Additionally, people living in affluent communities are more likely to drink healthy beverages, such as non-sugared tea rather than sodas. In Japan, green tea—a traditional Japanese drink—is popular as a non-sugared beverage. Green tea consumption is associated with good oral health [25]. Third, people living in affluent communities are less likely to have psychosocial stress because of there are more safety, good social capitals such as social connection and network, and social norms than that of deprived[26]. Psychosocial stress associated with

people's smoking status, which effect periodontal diseases causing tooth loss [27]. In addition, public safety in the community affects oral health by reducing the possibility of dental injuries. Dental injury was affected by community social environment [28].

In the present study, women's dental health was affected to a greater extent than men's health was by municipality-level income. Previous studies on other health outcomes have reported similar results. Compared to men, the self-rated health of women is considered to be affected to a greater extent by the neighborhood social environment [29]. Another study on self-rated health reported similar findings and the authors suggested that this might be because women tend to spend more time at home and in the community [30]. Thus, older women were more likely than men to communicate with neighbors. Therefore, women are more likely to be affected in their health behavior by neighbors though informal social control and social influence. A previous study in Japan demonstrated that, for older women, the distance to a dental clinic was an important factor for dental attendance, while distance was not significantly associated with access to dental care among older men [31]. Because many older women in Japan do not have a driver's license, public transportation is considered an important factor for access to dental clinic. Generally, in affluent areas, investment in public transportation is higher than in disadvantaged areas.

Public health implications

Community factors are important because they potentially affect the health of all residents in a given area. The present study revealed the importance of community-level socioeconomic status on oral health. Therefore, interventions should not only focus on individual efforts but also consider community-level social determinants underlying the oral health of a population. Therefore, after relevant factors are determined by future studies, *upstream* approaches, structural and environmental interventions for improving various social determinants of communities (e.g., smoking policies for public spaces, food policies for reducing sugar consumption, health care system reforms for improving access to preventive and curative care, and access to fluoride in water system or in school), are necessary for reducing oral health inequalities [32-34].

Limitation and strengths

This study has some limitations. First, this was a cross-sectional study; thus, we cannot

rule out the possibility of reverse causation. Prospective follow-up studies are required. Second, measurements were obtained from a self-administered questionnaire, even though the validity of self-reporting the number of remaining teeth was validated [35]. However, if we can obtain clinical measurements of remaining teeth, which are more accurate than self-administered questionnaires, the association between income variables and edentulousness will be strengthened. Third, there might have a potential bias because of many lack of case. The main strength of this study was its large sample size. In addition, our survey was conducted across an adequate number of municipalities with various characteristics and we used an appropriate statistical analysis. Therefore, the present study could legitimately describe the effects of community factors.

In conclusion, community-level income, as well as individual-level income, formed social gradients for edentulousness, even after accounting for individual- and community-level factors. Women living in municipalities with higher community-level income benefited in their oral health from the social environment.

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Table 1. The demographic distribution of variables by dental status (N=79,563).

Categorical variables		Dentulousness N (%)	Edentulousness N (%)	p-value
Sex	Male	34,083 (86.2)	5,467 (13.8)	0.798†
	Female	34,507 (86.2)	5,506 (13.8)	
Age	65-69ys	23,239 (94.6)	1,327 (5.4)	p<0.001†
	70-74ys	21,560 (90.3)	2,314 (9.7)	
	75-79ys	14,212 (83.2)	2,877 (16.8)	
	80-84ys	6,899 (72.8)	2,573 (27.2)	
	>84ys	2,680 (58.7)	1,882 (41.3)	
Marital status	Marital	52,769 (88.1)	7,115 (11.9)	p<0.001†
	Widowed	12,185 (78.6)	3,311 (21.4)	
	Divorced	2,007 (86.7)	307 (13.3)	
	Never married	1,316 (88.4)	173 (11.6)	
	Others	313 (82.4)	67 (17.6)	
Educational attainment	<6ys	1,120 (61.7)	694 (38.3)	p<0.001†
	6-9ys	27,979 (82.7)	5,853 (17.3)	
	10-12ys	25,428 (89.4)	3,023 (10.6)	
	>12ys	13,650 (91.3)	1,299 (8.7)	
	Others	413 (79.9)	104 (20.1)	
Continuous variables		Mean (SE)		
Density of dental clinic (per 10 thousand population)		4.45 (±0.837)	4.31 (±0.699)	p<0.001‡
Individual income (10 thousand US dollar*)		2.39 (±1.553)	1.95 (±1.467)	p<0.001‡
Municipality mean income (10 thousand US dollar*)		3.18 (±0.297)	3.09 (±0.285)	p<0.001‡

† p-value for chi-squared test.
‡ p-value for t-test.

* 1 US $=100 Japanese Yen

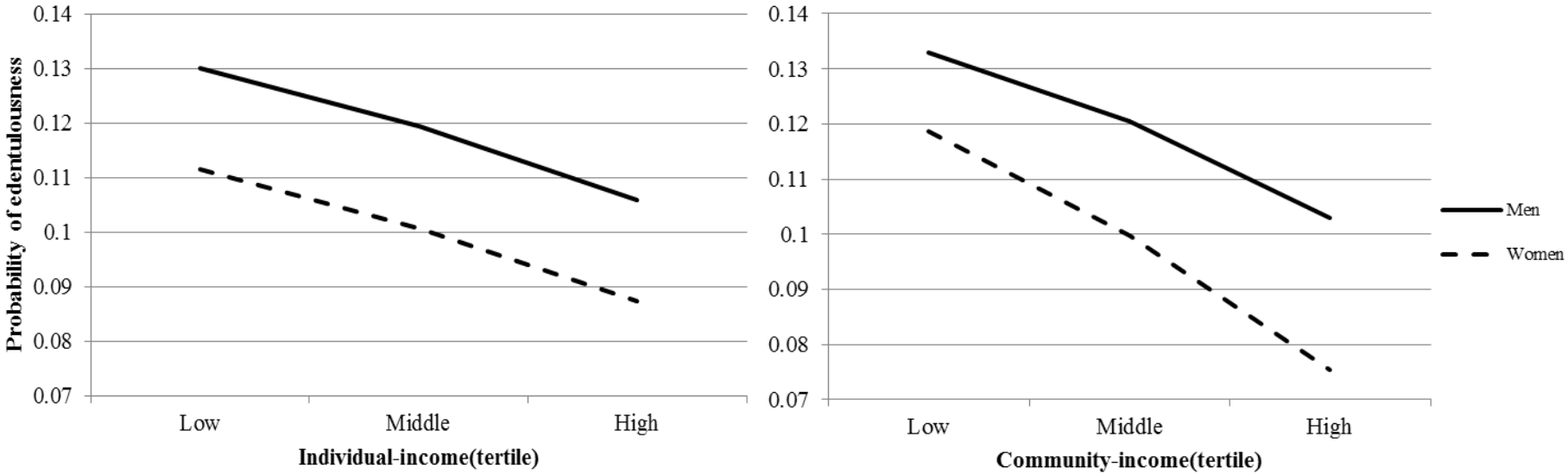
Table 2. Association of edentulousness with individual- and municipality-level variables determined by multilevel logistic regression (N=79,563).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Fixed effect						
Individual-variables						
Individual income (10 thousand US dollar)	0.85 (0.84 - 0.86)	0.87 (0.86 - 0.88)	0.90 (0.88 - 0.91)	0.90 (0.88 - 0.91)	0.90 (0.88 - 0.92)	0.90 (0.88 - 0.91)
Educational attainment (ref: ＞12ys)			1.00	1.00	1.00	1.00
＜6ys			2.19 (1.94 - 2.47)	2.19 (1.94 - 2.47)	2.19 (1.94 - 2.48)	2.19 (1.93 - 2.47)
6-9ys			1.61 (1.50 - 1.73)	1.61 (1.51 - 1.73)	1.62 (1.51 - 1.73)	1.62 (1.51 - 1.73)
10-12ys			1.15 (1.07 - 1.24)	1.15 (1.07 - 1.24)	1.16 (1.08 - 1.24)	1.16 (1.08 - 1.25)
Others			1.79 (1.41 - 2.28)	1.80 (1.42 - 2.28)	1.80 (1.42 - 2.28)	1.80 (1.42 - 2.29)
Communitu-variables						
Community income (10 thousand US dollar)	0.37 (0.22 - 0.63)	0.39 (0.25 - 0.61)	0.41 (0.27 - 0.63)	0.43 (0.27 - 0.67)	0.43 (0.27 - 0.67)	0.53 (0.33 - 0.85)
Density of dental clinic (per 10 thousand population)				0.96 (0.78 - 1.19)	0.96 (0.78 - 1.19)	0.96 (0.78 - 1.18)
Interaction term (Sex*Individual income)					0.98 (0.95 - 1.02)	
Interaction term (Sex*Community income)						0.63 (0.54 - 0.73)
Random effects (SE)	0.148 (0.039)	0.105 (0.028)	0.095 (0.026)	0.095 (0.026)	0.095 (0.026)	0.095 (0.026)
Median odds ratio	1.443	1.362	1.342	1.342	1.342	1.342

Model 1: Adjusted for individual- and community-level incomes.
Model 2: Model 1 + age, sex, and marital status.
Model 3: Model 2 + educational attainment.
Model 4 (full model): Model 3 + community-variables (density of dental clinic).
Model 5,6: Model 4 + Each interaction terms.

* 1 US $=100 Japanese Yen

Figure. Gender difference in the association between individual- and community- level incomes and probability of edentulousness (N=79,563).



Appendix. Sample Questionnaire (Excerpt from JAGES2010 Questionnaire)

１）ご自身の歯の状態はいかがですか。

1. 自分の歯が 20 本以上ある　　2. 自分の歯が 10～19 本ある
3. 自分の歯が１～９本ある　　4. 自分の歯は０本である

２）性別　1. 男　2. 女

３）あなたの年齢を教えてください。　満　歳

４）あなたが受けられた学校教育は何年間でしたか。

1. ６年未満　2. ６～９年　3. １０～１２年　4. １３年以上　5. その他

５）あなたの婚姻状態は、次のうちのどれにあてはまりますか。

1. 配偶者がいる　2. 死別した　3. 離別した　4. 未婚である　5. その他

６）あなたと生計を共にしている世帯人数は何人ですか。

生計を共にしている世帯人数（あなたを含めて）　人

７）６）で答えた世帯全体の合計収入額（年金を含みます）は、平成 21 年１年間で、次のうちどれにあてはまりますか（税引き前で）。あてはまる番号一つに○をつけてください。

1. 50 万円未満　2. 50～100 万円未満　3. 100～150 万円未満
4. 150～200 万円未満　5. 200～250 万円未満　6. 250～300 万円未満
7. 300～400 万円未満　8. 400～500 万円未満　9. 500～600 万円未満
10. 600～700 万円未満　11. 700～800 万円未満　12. 800～900 万円未満
13. 900～1,000 万円未満　14. 1,000～1,200 万円未満　15. 1,200 万円以上