【問 18】 あなたの運動習慣や服薬状況についておうかがいします。

1）「自分ひとり」で、運動することがありますか。

1．週４回以上　2．週２～３回　3．週１回　4．月１～３回　5．年に数回　6．ほとんどない

2）「家族・友人・仲間」と一緒に、運動することがありますか。

1．週４回以上　2．週２～３回　3．週１回　4．月１～３回　5．年に数回　6．ほとんどない

3）「家族・友人・仲間」と一緒に、趣味の活動（運動は除く）を行うことがありますか。

1．週４回以上　2．週２～３回　3．週１回　4．月１～３回　5．年に数回　6．ほとんどない

4）あなたは地域の高齢者に対して「運動やスポーツの実施を支援する活動」をどの程度行いますか。
例）健康推進員、介護予防ボランティア、町内会のラジオ体操担当など

1．週４回以上　2．週２～３回　3．週１回　4．月１～３回　5．年に数回　6．ほとんどない

5）あなたが毎日飲んでいる薬のうち，医師から処方されている薬は何種類ありますか？

1．な　し　2．１～２種類　3．３～４種類　4．５種類以上　5．わからない

6）以下にあげる薬で飲んでいるもの**すべてに**○をつけてください.

1．睡眠薬　2．精神安定剤　3．血圧を下げる薬（高血圧の薬）　4．１～３の薬は飲んでいない

【問 19】 お住まいについておうかがいいたします。

1）お住まいは一戸建てですか、集合住宅ですか。

1．一戸建て　2．集合住宅

↓

2）お住まいは２階以上にありますか

1．いいえ（１階である）　2．はい

↓

3）（２階以上にある方）お住まいにエレベーターは設置されていますか

1．はい・設置されている　2．いいえ・設置されていない

【問 20】 インターネットについておうかがいします。

1）あなたは過去１２か月の間に、インターネットや電子メールを使いましたか。

1．いいえ　2．はい（自分で使った）　3．はい（家族や友人に頼んで使ってもらった）

↓

2）インターネットの使用目的について、あてはまる番号**すべてに○を**つけてください。

1．健康や医療に関する情報収集　2．医療機関の検索　3．薬やビタミン剤の購入
4．友人や家族とのコミュニケーション　5．（食品などの）買い物　6．ネット証券（株）・銀行
7．フェイスブック　8．ツイッター　9．その他の SNS（ネット上の交流サイト）

3）主にどこからインターネットを使用しますか。あてはまる番号**１つに○を**つけてください。

1．自宅　2．職場　3．図書館　4．公民館　5．携帯電話　6．その他（　　）

これで調査票は終了です。長時間にわたりご協力ありがとうございました。

E

【問 15】 あなたはCOPD（シー・オー・ピー・ディー）という病気を知っていますか。

1．どんな病気かよく知っている　2．名前は聞いたことがある　3．知らない

【問 16】 あなたの飲酒行動についておうかがいします。

1）現在、ビールコップ１杯程度の少量の飲酒で、すぐ顔が赤くなる体質が、ありますか？

1．あ　る　　2．な　い　　3．わからない

2）飲酒を始めた頃の1～2年間は、ビールコップ１杯程度の少量飲酒で、すぐ顔が赤くなる体質がありましたか？

1．あった　　2．なかった　　3．わからない

3）あなたは今までに、飲酒を減らさなければいけないと思ったことがありますか。

1．あった　　2．なかった　　3．飲めない・飲まない

4）あなたは今までに、飲酒を批判されて腹が立ったり、いらだったりしたことがありますか。

1．あった　　2．なかった　　3．飲めない・飲まない

5）あなたは今までに、飲酒に後ろめたい気持ちや罪悪感を持ったことがありますか。

1．あった　　2．なかった　　3．飲めない・飲まない

6）あなたは今までに、朝酒や迎え酒を飲んだことがありますか。

1．あった　　2．なかった　　3．飲めない・飲まない

7）お酒をどのくらいの頻度で飲みますか。

1．飲まない　　2．毎日飲む　　3．週に５～６日　　4．週に３～４日
5．週に１～２日　　6．月に１～３日　　7．月に１日未満

↓

8）お酒を飲む日は、１日にどのくらい飲みますか。
（日本酒１合＝ビール中ビン１本＝ウイスキーシングル２杯と考えてください）

1．１合未満　　2．１合～２合未満　　3．２合～３合未満
4．３合～４合未満　　5．４合～５合未満　　6．５合以上

【問 17】 最近のからだの調子についておうかがいします。

1）風邪をひいていないのにたんがからむことがありますか。 ― 1．あ　る　　2．な　い

2）喘鳴（ぜいぜい、ヒューヒュー）がよくありますか。 ― 1．あ　る　　2．な　い

3）今現在（もしくは今まで）アレルギーの症状はありますか。 ― 1．あ　る　　2．な　い

4）この３ヶ月間に、いびきをかきましたか。

1．ほとんど毎日	2．ときどき	3．全くかかなかった
4．一人暮らし、あるいは家族と別室で寝るため、わからない		

【問 18】 喫煙行動についておうかがいします。

1）過去１ヶ月間に自分以外の人が吸っていたタバコの煙を吸う機会（受動喫煙）がありましたか。

1．ほぼ毎日　2．週に数回程度　3．週に１回程度　4．月に１回程度　5．全くなかった

2）あなたの周りで禁煙が不十分だと思われる場所がありますか？ あてはまるものに<u>すべてに</u>○を付けてください。

1．飲食店	2．路　上	3．娯楽施設	4．バス停
5．ＪＲ・私鉄の駅	6．旅館・ホテル	7．自　宅	8．職　場
9．会合、集会の場	10．その他（　　）		

3）不特定、または多数の人が出入りする施設での受動喫煙を防止するためのルールを定めることについてどう思いますか。

1．賛　成	2．どちらかといえば賛成	3．どちらかといえば反対
4．反　対	5．わからない	

4）あなたは、喫煙していた、または、現在も喫煙していますか。

1．喫煙していた、または、現在も喫煙している　　2．生涯喫煙したことはない

↓

5）１日に何本くらいタバコを吸いますか。
（吸っていましたか）　　本

↓

これで終わりです。
ご協力ありがとう
ございました

6）何歳から何歳までタバコを吸っていますか （吸っていましたか）

歳から　　歳まで

↑※現在も喫煙している場合は、現在の年齢を記入してください

7）ご自身のタバコの煙が周囲の人に与える影響を気にしていますか。　1．はい　2．いいえ

8）周囲に<u>非</u>喫煙者がいる際、タバコを吸うことを控えますか。　1．はい　2．いいえ

これで調査票は終了です。長時間にわたりご協力ありがとうございました。

Ⅱ．研究成果の刊行に関する一覧

1. 相田潤，近藤克則：【健康格差とソーシャル・キャピタルの『見える化』】 ソーシャル・キャピタルと健康格差．医療と社会 2014，24(1)：57-74.
2. 松山祐輔，相田潤，竹内研時，伊藤奏，中安美枝子，小山史穂子，長谷晃広，坪谷透，小坂健：歯周病と脳血管疾患の関連　歯周病測定指標の特性を考慮したメタアナリシス．口腔衛生学会雑誌 2014，64(1)：2-9.
3. 安本恵，相田潤，滝波修一，森田康彦，本多丘人：バングラデシュにおける子供の口腔疾患と社会行動的リスク要因．北海道歯学雑誌 2014，34(2)：77-86.
4. Yamamoto T, Kondo K, Aida J, Suzuki K, Misawa J, Nakade M, Fuchida S, Hirata Y, group J: Social determinants of denture/bridge use: Japan gerontological evaluation study project cross-sectional study in older Japanese. BMC oral health 2014, 14:63.
5. Yamamoto T, Kondo K, Aida J, Fuchida S, Hirata Y, group J: Association between the longest job and oral health: Japan Gerontological Evaluation Study project cross-sectional study. BMC oral health 2014, 14(1):130.
6. Tsuboya T, Aida J, Kawachi I, Katase K, Osaka K: Early life-course socioeconomic position, adult work-related factors and oral health disparities: cross-sectional analysis of the J-SHINE study. BMJ Open 2014, 4:e005701.
7. Takeuchi K, Aida J, Ito K, Furuta M, Yamashita Y, Osaka K: Nutritional Status and Dysphagia Risk among Community-Dwelling Frail Older Adults. The journal of nutrition, health & aging 2014, 18(4):352-357.
8. Murakami K, Aida J, Ohkubo T, Hashimoto H: Income-related inequalities in preventive and curative dental care use among working-age Japanese adults in urban areas: a cross-sectional study. BMC oral health 2014, 14(1):117.
9. Matsuyama Y, Aida J, Takeuchi K, Tsakos G, Watt RG, Kondo K, Osaka K: Inequalities of dental prosthesis use under universal healthcare insurance. Community Dent Oral Epidemiol 2014, 42(2):122-128.
10. Koyama S, Aida J, Kawachi I, Kondo N, Subramanian SV, Ito K, Kobashi G, Masuno K, Kondo K, Osaka K: Social Support Improves Mental Health among the Victims Relocated to Temporary Housing following the Great East Japan Earthquake and Tsunami. The Tohoku journal of experimental medicine 2014, 234(3):241-247.
11. Kanamori S, Kai Y, Aida J, Kondo K, Kawachi I, Hirai H, Shirai K, Ishikawa Y, Suzuki K, Group J: Social Participation and the Prevention of Functional Disability in Older Japanese: The JAGES Cohort Study. PLoS One 2014, 9(6):e99638.
12. Bönecker M, Pordeus I, Peres M, Aida J: Epidemiology of oral health problems and trends. In: Promoting the Oral Health of Children Theory & Practice. 2nd edn. Edited by Sheiham A, Moysés S, Watt R, Bönecker M: QUINTESSENCE; 2014.
13. 相田潤，近藤克則：歯科疾患．In：健康の社会的決定要因　疾患・状態別「健康格差」レビュー．edn. Edited by 近藤克則．東京：日本公衆衛生協会；2013：76-80.
14. 相田潤，近藤克則：ソーシャルキャピタルと健康．In：健康の社会的決定要因　疾患・状態別「健康格差」レビュー．edn. Edited by 近藤克則．東京：日本公衆衛生協会；2013：84-87.
15. 相田潤，Kawachi I，Subramanian SV，近藤克則：災害とソーシャル・キャピタルと健康．In：ソーシャル・キャピタルと健康政策　地域で活用するために．edn. Edited by イチローカワチ，高尾総司，SV スブラマニアン．東京：日本評論社；2013：257-300.
16. 曽根稔雅，中谷直樹，遠又靖丈，相田潤，大久保一郎，大原里子，大渕修一，杉山みち子，安村誠司，鈴木隆雄 et al：介護予防サービス利用者における生活機能の予後予測及び効果的な運動器の機能向上プログラムの実施内容に対する評価．日本公衆衛生雑誌 2013，68(1)：11-21.
17. 三辺正人，河野寛二，原井一雄，相田潤，野村義明：重度歯周炎患者に対する経口抗菌療法を併用した非外科治療の臨床および細菌学的評価．日本歯周病学会会誌 2013，55(2)：156-169.

18. 近藤克則 (ed.): 健康の社会的決定要因　疾患・状態別「健康格差」レビュー. 東京: 日本公衆衛生協会; 2013.
19. Tsakos G, Sabbah W, Chandola T, Newton T, Kawachi I, Aida J, Sheiham A, Marmot MG, Watt RG: Social relationships and oral health among adults aged 60 years or older. Psychosom Med 2013, 75(2):178-186.
20. Takeuchi K, Aida J, Kondo K, Osaka K: Social participation and dental health status among older Japanese adults: a population-based cross-sectional study. PLoS One 2013, 8(4):e61741.
21. Ota J, Yamamoto T, Ando Y, Aida J, Hirata Y, Arai S: Dental health behavior of parents of children using non-fluoride toothpaste: a cross-sectional study. BMC oral health 2013, 13:74.
22. Hayasaka K, Tomata Y, Aida J, Watanabe T, Kakizaki M, Tsuji I: Tooth loss and mortality in elderly Japanese adults: effect of oral care. J Am Geriatr Soc 2013, 61(5):815-820.
23. Aida J, Kondo K, Kawachi I, Subramanian SV, Ichida Y, Hirai H, Kondo N, Osaka K, Sheiham A, Tsakos G et al: Does social capital affect the incidence of functional disability in older Japanese? A prospective population-based cohort study. J Epidemiol Community Health 2013, 67(1):42-47.
24. Aida J, Kawachi I, Subramanian SV, Katsunori K: Disaster, Social Capital, and Health. In: Global Perspectives on Social Capital and Health. edn. Edited by Kawachi I, Takao S, Subramanian SV. New York: Springer; 2013: 167-187.
25. 曽根稔雅, 中谷直樹, 遠又靖丈, 相田潤, 大久保一郎, 大原里子, 大渕修一, 杉山みち子, 安村誠司, 鈴木隆雄 et al: 介護予防サービス利用者における日常生活の過ごし方と要介護認定等の推移との関連. 日本衛生学雑誌 2012, 67(3):401-407.
26. 山本龍生, 近藤克則, 渕田慎也, 相田潤, 中出美代, 平田幸夫: 質問紙調査による口腔関連指標の妥当性：愛知老年学的評価研究 (AGES) プロジェクト. ヘルスサイエンス・ヘルスケア 2012, 12(1):4-12.
27. 山本龍生, 阿部智, 大田順子, 安藤雄一, 相田潤, 平田幸夫, 新井誠四郎: 2010 年における学齢期のフッ化物配合歯磨剤の使用状況. 口腔衛生学会雑誌 2012, 62(4):410-417.
28. 伊藤奏, 相田潤, 若栗真太郎, 野口有紀, 小坂健: 口腔機能向上プログラムの参加率向上に関する要因の検討. 老年歯科医学 2012, 27(3):285-290.
29. 伊藤奏, 相田潤, 若栗真太郎, 野口有紀, 小坂健: 居宅介護支援事業所と歯科との連携に関する実態調査および連携の要因についての調査. 老年歯科医学 2012, 27(2):114-120.
30. Yamamoto T, Kondo K, Misawa J, Hirai H, Nakade M, Aida J, Kondo N, Kawachi I, Hirata Y: Dental status and incident falls among older Japanese: a prospective cohort study. BMJ Open 2012, 2(4).
31. Yamamoto T, Kondo K, Hirai H, Nakade M, Aida J, Hirata Y: Association between self-reported dental health status and onset of dementia: a 4-year prospective cohort study of older Japanese adults from the Aichi Gerontological Evaluation Study (AGES) Project. Psychosom Med 2012, 74(3):241-248.
32. Takeuchi K, Aida J, Morita M, Ando Y, Osaka K: Community-level socioeconomic status and parental smoking in Japan. Social science & medicine 2012, 75(4):747-751.
33. Aida J, Kondo K, Hirai H, Nakade M, Yamamoto T, Hanibuchi T, Osaka K, Sheiham A, Tsakos G, Watt RG: Association between dental status and incident disability in an older Japanese population. J Am Geriatr Soc 2012, 60(2):338-343.

Ⅲ. 研究成果の刊行物・別刷

（一部のみ抜粋）

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PLOS | ONE

Social Participation and Dental Health Status among Older Japanese Adults: A Population-Based Cross-Sectional Study

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Abstract

Background: Although social participation is a key determinant of health among older adults, few studies have focused on the association between social participation and dental health. This study examined the associations between social participation and dental health status in community-dwelling older Japanese adults.

Methods and Findings: In 2010, self-administered postal questionnaires were distributed to all people aged ≥65 years in Iwanuma City, Japan (response rate, 59.0%). Data from 3,517 respondents were analyzed. Data on the number of remaining natural teeth, for determining the dental health status, and social participation were obtained using self-administered questionnaires. The number, type, and frequency of social activities were used to assess social participation. Social activities were political organizations or associations, industrial or professional groups, volunteer groups, senior citizens' clubs, religious groups or associations, sports groups, neighborhood community associations, and hobby clubs. Using ordinal logistic regression, we calculated the odds ratios (OR) and 95% confidence intervals (95% CI) for an increase in category of remaining teeth based on the number, type, and frequency of social activities. Sex, age, marital status, current medical history, activity of daily living, educational attainment, and annual equivalent income were used as covariates. Of the respondents, 34.2% reported having ≥20 teeth; 27.1%, 10–19 teeth; 26.3%, 1–9 teeth; and 12.4%, edentulousness. Social participation appeared to be related with an increased likelihood of having a greater number of teeth in old age, even after adjusting for covariates (OR = 1.30, 95% CI = 1.10–1.53). Participation in sports groups, neighborhood community associations, or hobby clubs was significantly associated with having more teeth.

Conclusions: Our results suggest a protective effect of social participation on dental health. In particular, participation in sports groups, neighborhood community associations, or hobby clubs might be a strong predictor for retaining more teeth in later life.

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Introduction

Enhanced social participation, a social determinant of health [1,2], is one of the 3 pillars of a World Health Organization (WHO) policy framework for an active aging society [3]. Social participation is a source of social relations and describes a person's participation in formal and informal group activities [4,5,6]. As many older retired people are assumed to have more time to participate in other activities, the role of social participation in the health of older adults is increasing in today's aging society.

Previous studies have examined the association between social participation and various health outcomes. A meta-analysis determined that social participation reduced the risk for mortality and that the magnitude of this effect was comparable with smoking cessation [7]. A study conducted in Asia reported that maintaining or initiating social participation in later life benefited the mental health of older adults [8]. A study conducted in Japan reported that lack of social participation was significantly related to an increased risk for onset of long-term care insurance certification [9]. In addition to the effect itself, social participation is important because it is a component of social capital [10]. According to Putnam, social capital refers to "features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit" [11]. Recent studies have demonstrated a positive association between social capital and various health outcomes, including dental health [12,13,14,15,16,17].

Social participation is also considered to affect dental health [18,19]. Previous studies have demonstrated that lower levels of social participation were associated with a higher risk for

edentulism [18] or periodontitis [19]. There are 2 plausible relationship mechanisms between social participation and dental health: social network as a main effect, and stress buffering [20]. The main effect of social participation is obtained from social relationships, and this mechanism is beneficial regardless of whether individuals are under stress. Participation in a broad range of social relationships develops a person's social network. Individuals in a social network are subject to social controls and peer pressure that influence normative dental health behaviors (e.g., developing good dental habits and quitting smoking). For example, the cessation of smoking in one person appears to be highly related to the smoking behavior of others nearby in that person's social network [21]. Social network ties also provide multiple sources of information that could influence behaviors relevant to oral health, result in the effective use of available dental health services, or help people avoid stressful or other high-risk situations. In addition to this main effect, stress buffering is also considered a pathway to good dental health. A systematic review of the literature suggests that psychological stress causes periodontal disease, which is a key risk factor for tooth loss [22]. Social networks are a source of social support, which in turn provides psychological and material resources intended to benefit an individual's ability to cope with stress. As social support promotes less threatening interpretations of adverse events and effective coping strategies, it can shield individuals from the effects of stressful experiences. This mechanism is called stress buffering.

Despite a recent increase in studies on social participation and health, only a small number of studies have focused on the association between social participation and oral health. In addition, previous oral epidemiological studies have defined social participation as only belonging or not belonging to social relationships, or as high or low frequency of social engagement. A meta-analysis revealed that definitions of social participation mostly focused on questions of who, how, what, with whom, and where [6]. To our knowledge, the present study is the first to focus on the number, type, and frequency of social activities. This study aimed to quantify the associations between social participation and dental health status in community-dwelling older Japanese adults.

Methods

Study sample

The present analysis was based on a subset of the Japan Gerontological Evaluation Study (JAGES) project data. The JAGES project is an ongoing prospective cohort study investigating factors associated with the loss of health related to functional decline or cognitive impairment among individuals aged 65 years or older. In 2010, self-administered postal questionnaires were distributed to all people aged ≥65 years in Iwanuma City, Miyagi Prefecture, Japan (n = 8,576), and 5,058 (response rate, 59.0%) people returned the questionnaires. After excluding respondents who failed to provide information on sex, dental health status, or social participation, the data from 3,517 respondents were analyzed. If the respondents did not respond to the other variables, the corresponding observations were assigned to "missing" categories. Ethical approval for the study was obtained from the Ethics Committee at Tohoku University and Nihon Fukushi University.

Outcome variable

The number of remaining natural teeth, derived from responses collected through the self-administered questionnaire, was used as an indicator of dental health status. Respondents were asked to classify their dental health status into one of 4 categories: ≥20 teeth remaining, 10–19 teeth remaining, 1–9 teeth remaining, or no teeth remaining.

Main predictors

Social participation was defined as the person's involvement in social activities. First, respondents were asked whether they belonged to political organizations or associations, industrial or professional groups, volunteer groups, senior citizens' clubs, religious groups or associations, sports groups, neighborhood community associations, or hobby clubs. Second, respondents were asked to indicate the frequency of participation in each group: 2–3 times per week, once per week, several times per month, several times per year, or almost never. As there were very few "2–3 times per week" responses for 6 groups (political organizations or associations, industrial or professional groups, volunteer groups, senior citizens' clubs, religious groups or associations, and neighborhood community associations), we re-categorized these social participation variables: once or more per week, several times per month, several times per year, almost never. As our study also focused on the number of social activities, we calculated the numbers of social activities and created 6 categories: 0 groups, 1 group, 2 groups, 3 groups, 4 groups, and ≥5 groups.

Covariates

It was assumed that physical health status was associated with both social participation and dental health status. Activity of daily living and current medical history were used as indicators of physical health status. Activity of daily living was categorized as independent, partially dependent, and dependent. Current medical history was measured by the question, "Do you receive treatment now?" to which respondents answered "yes" or "no." Sex, age, and marital status were used as socio-demographic characteristics. Age groups were categorized as 65–69, 70–74, 75–79, 80–84, and ≥85 years. Marital status was categorized as married, widowed, separated, never married, and other. Educational attainment and annual equivalent income were used as indicators of socioeconomic status. Educational attainment was categorized as <6, 6–9, 10–12, and ≥13 years. Annual equivalent income was divided into quartiles: lowest, low-middle, high-middle, and highest.

Statistical analysis

Descriptive statistics were used to characterize the respondents. We performed ordinal logistic regressions to examine the associations between social participation and dental health status. We calculated the odds ratios (OR) and 95% confidence intervals (95% CI) for an increase in the remaining teeth category based on the number, type, and frequency of social activities. To estimate the overall effect of social participation, we used a dichotomized variable of social participation (1 = participating in ≥1 groups, 0 = not participating in any group). Variables on social participation were included separately in the different models. In the univariate model (Model 1), we calculated the crude OR for dental health status based on the number of social activities and the type and frequency of social participation. In the multivariable model (Model 2), we added all covariates into the univariate model. In order to assess the public health impact of social participation, we calculated the population-attributable fraction (PAF) of having ≥20 teeth to social participation. The PAF is generally defined as the reduction in the burden of disease (or risk factor) that would be achieved if the population had been entirely unexposed, compared with its current exposure pattern [23]. In this study, we treated the PAF as the increase in the number of people with ≥20 remaining

teeth that would be achieved if the entire population participated in some kind of social group, compared with its current participation pattern. We calculated a PAF for ≥20 remaining teeth because the retention of a minimum of 20 functional natural teeth at the age of ≥65 years is a goal for oral health specified by the WHO/*Federation Dentaire Internationale* in 2000 [24]. The goal for an acceptable level of oral health determined by the Japan Dental Association is the retention of at least 20 functional teeth until the age of 80 years (8020 movement). A previous study also indicated that among older people, those with ≥20 teeth had higher food intakes than those with ≤19 teeth [25]. All analyses were performed using SPSS statistical software (version 17.0, SPSS, Chicago, IL).

Results

The demographic and health characteristics of all respondents (n = 3,517; average age, 73.5 years for men and 75.0 years for women) in the study are shown in Tables 1 and 2. Of the respondents, 34.2% reported having ≥20 teeth, 27.1% reported having 10–19 teeth, 26.3% reported having 1–9 teeth, and 12.4% reported having no teeth. Of the respondents, 13.9% belonged to political organizations or associations, 15.2% to industrial or professional groups, 16.4% to volunteer groups, 15.7% to senior citizens' clubs, 7.3% to religious groups or associations, 24.5% to sports groups, 46.8% to neighborhood community associations, and 41.1% to hobby clubs.

Of all respondents, 69.6% participated in ≥1 groups, and 30.4% did not participate in any group. Compared to the non-participants, participants had significantly higher odds of having a greater number of teeth (OR = 2.40, 95% CI = 2.10–2.74). After adjusting for sex, age, marital status, current medical history, activity of daily living, educational attainment, and annual equivalent income, social participation appeared to be related with an increased likelihood of having a greater number of teeth in old age (OR = 1.30, 95% CI = 1.10–1.53).

Table 3 illustrates the association between dental health status and the number of social activities. Participating in ≥1 groups was significantly associated with odds of having more remaining teeth that were more than twice as high as compared with non-participation (Model 1). After adjusting for all covariates, participating in 4 groups was associated with significantly higher odds (OR = 1.46, 95% CI = 1.11–1.93) of having more remaining teeth compared with non-participation (Model 2). Table 4 shows the association between dental health status and the type and frequency of social participation. The groups significantly associated with a higher number of remaining teeth were industrial or professional groups, volunteer groups, sports groups, neighborhood community associations, and hobby clubs (Model 1). After adjusting for all covariates, participating in sports groups (2–3 times per week, OR = 1.31, 95% CI = 1.01–1.69), neighborhood community associations (several times per year, OR = 1.19, 95% CI = 1.02–1.39), or hobby clubs (2–3 times per week, OR = 1.36, 95% CI = 1.05–1.76; once per week, OR = 1.39, 95% CI = 1.10–1.75; several times per year, OR = 1.41, 95% CI = 1.11–1.81) was significantly associated with having more teeth (Model 2). With the exception of these 3 groups, although most types of participation were associated with higher odds of having more teeth, the associations were explained by covariates. This indicates that healthier people tend to have more teeth and participate in groups.

The PAFs, or the contribution of social participation to having ≥20 teeth, are shown in Tables 3 and 4. The PAFs for the number of social activities and 3 types of social participation variables that were significantly associated with dental health (i.e., sports groups, neighborhood community associations, and hobby clubs) were 7.5%–31.6%. The largest PAF (31.6%) was for participation in ≥1 social groups.

Table 1. Characteristics of respondents.

	n	%		n	%
Sex			**Educational attainment (years)**		
Men	1,681	47.8	<6	86	2.4
Women	1,836	52.2	6–9	1,071	30.5
Age (years)			10–12	1,521	43.2
65–69	1,147	32.6	≥13	762	21.7
70–74	950	27.0	Missing	77	2.2
75–79	649	18.5	**Annual equivalent income (quartiles)**		
80–84	418	11.9	Lowest	718	20.4
≥85	346	9.8	Low-middle	731	20.8
Missing	7	0.2	High-middle	801	22.8
Marital status			Highest	792	22.5
Married	2,416	68.7	Missing	475	13.5
Widowed	855	24.3	**Number of remaining natural teeth**		
Separated	111	3.2	≥20	1,203	34.2
Never married	50	1.4	10–19	952	27.1
Other	28	0.8	1–9	925	26.3
Missing	57	1.6	No	437	12.4
Current medical history			**Number of social activities (groups)**		
Yes	2,741	77.9	0	1,068	30.4
No	731	20.8	1	749	21.3
Missing	45	1.3	2	644	18.3
Activity of daily living			3	456	13.0
Independent	3,155	89.7	4	281	8.0
Partially dependent	208	5.9	≥5	319	9.1
Dependent	122	3.5			
Missing	32	0.9			

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Discussion

Our study demonstrates a significant positive association between social participation and dental health status in a representative sample of men and women aged ≥65 years in a municipality in Japan. Among those with ≥20 remaining teeth, 31.6% of cases in the population might be attributed to participation in ≥1 social groups. To our knowledge, no published reports have examined the associations between dental health status and the number, type, and frequency of social activities. In relation to the type and frequency of social participation, frequent participation in sports groups, rare participation in neighborhood community associations, or participation in hobby clubs with little regard to frequency were significantly associated with dental health status, even after adjusting for demographic variables and social class indicators. In relation to the number of social activities, almost all amounts of social participation were significantly positively associated with dental health.

Our results may support the earlier-described mechanisms linking social participation and dental health status (i.e., social network as a main effect and stress buffering). There was a

Table 2. Characteristics of respondents according to type and frequency of social participation.

	2–3 times per week n (%)	Once per week n (%)	Several times per month n (%)	Several times per year n (%)	Almost never n (%)
Type and frequency of social participation					
Political organization or association	45 (1.3)	32 (0.9)	90 (2.6)	321 (9.1)	3,029 (86.1)
Industrial or professional group	56 (1.6)	36 (1.0)	126 (3.6)	318 (9.0)	2,981 (84.8)
Volunteer group	52 (1.5)	59 (1.7)	192 (5.5)	275 (7.8)	2,939 (83.6)
Senior citizens' club	27 (0.8)	61 (1.7)	185 (5.3)	280 (8.0)	2,964 (84.3)
Religious group or association	23 (0.7)	34 (1.0)	81 (2.3)	120 (3.4)	3,259 (92.7)
Sports group	259 (7.4)	245 (7.0)	183 (5.2)	176 (5.0)	2,654 (75.5)
Neighborhood community association	44 (1.3)	61 (1.7)	282 (8.0)	1,260 (35.8)	1,870 (53.2)
Hobby club	284 (8.1)	350 (10.0)	500 (14.2)	311 (8.8)	2,072 (58.9)

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significant association with better dental health status for participants in the groups with higher social participation rates. In groups with high participation rates that include many social ties, people may easily develop social networks and receive social support.

In addition to these positive effects of social participation on health, social participation can have negative effects on health. Social networks provide opportunities for conflict, exploitation, stress transmission, misguided attempts to help, and feelings of loss and loneliness [20]. These potentially negative aspects of social networks can cause psychological stress, which in turn adversely affects dental health. The results of this study showed no significant association between frequent participation in neighborhood community associations and dental health, but there was a significant association between relatively rare participation and dental health. The negative effects of social participation on health may be a reason for this. Participation in neighborhood community associations might include obligatory activities characterized by the negative aspects of social networks. People who frequently participate in obligatory activities may experience stress, leading to oral disease. Therefore, frequent participation in neighborhood community associations might not be significantly associated with having more teeth. Similarly, where participation in $\geq$5 groups is concerned, social participation might not be significantly associated with having more teeth for an increase in the type of social participation that has negative effects on health.

Our findings are generally consistent with those of previous studies indicating that participating in social activities benefits dental health status among middle-aged and older people. Rodrigues et al. suggested that social participation is significantly associated with a lower prevalence of edentulism among older adults [18]. Merchant et al. also suggested that men who participate in religious meetings are associated with a reduced risk of developing periodontitis [19].

To our knowledge, no study has specifically examined the differences between men and women in relation to the association between social participation and dental health status, though previous work has indicated that such differences exist. Among women, participation in social networks may increase levels of psychological stress [26]. In our study, 75.3% of men participated in $\geq$1 groups compared to 64.5% of women. However, with respect to the main results, we found few differences between men and women.

The results of this study have public health implications. Our goal was to estimate the PAF associated with participation in social activities (compared to non-participation) for having $\geq$20 remaining teeth. The largest PAF (31.6%) was for participation in $\geq$1 social groups, which implies that in 31.6% of cases in the population, presence of $\geq$20 remaining teeth may be attributed to

Table 3. Association of dental health status with number of social activities determined by ordinal logistic regression.

	Model 1	Model 2		
	Crude OR (95% CI)	Adjusted OR [a] (95% CI)	n of ≥20 teeth (%)	PAF [b] (%)
Number of social activities (groups)				31.6
0	1.00	1.00	250 (23.4)	
1	2.21 (1.86–2.62)	1.31 (1.07–1.59)	279 (37.2)	
2	2.22 (1.85–2.65)	1.21 (0.98–1.49)	231 (35.9)	
3	2.84 (2.32–3.48)	1.36 (1.07–1.72)	194 (42.5)	
4	2.90 (2.28–3.70)	1.46 (1.11–1.93)	125 (44.5)	
≥5	2.31 (1.84–2.90)	1.25 (0.96–1.62)	124 (38.9)	

OR = odds ratio; CI = confidence interval.
[a]Odds ratio adjusted for sex, age, marital status, current medical history, activity of daily living, educational attainment, and annual equivalent income.
[b]Population-attributable fraction.
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Table 4. Association of dental health status with type and frequency of social participation determined by ordinal logistic regression.

	Model 1	Model 2		
	Crude OR (95% CI)	Adjusted OR[a] (95% CI)	n of ≥20 teeth (%)	PAF[b] (%)
Type and frequency of social participation				
Political organization or association				1.4
Once or more per week	1.15 (0.77–1.74)	0.97 (0.61–1.53)	26 (33.8)	
Several times per month	1.33 (0.91–1.95)	1.06 (0.69–1.61)	35 (38.9)	
Several times per year	1.14 (0.93–1.41)	0.89 (0.70–1.11)	120 (37.4)	
Almost never	1.00	1.00	1,022 (33.7)	
Industrial or professional group				3.6
Once or more per week	1.29 (0.88–1.87)	1.03 (0.68–1.58)	33 (35.9)	
Several times per month	1.75 (1.26–2.44)	1.17 (0.82–1.67)	55 (43.7)	
Several times per year	1.51 (1.22–1.87)	1.05 (0.83–1.32)	132 (41.5)	
Almost never	1.00	1.00	983 (33.0)	
Volunteer group				4.3
Once or more per week	1.38 (0.98–1.96)	1.11 (0.76–1.61)	44 (39.6)	
Several times per month	1.85 (1.41–2.42)	1.31 (0.97–1.76)	89 (46.4)	
Several times per year	1.37 (1.10–1.72)	1.02 (0.79–1.31)	108 (39.3)	
Almost never	1.00	1.00	962 (32.7)	
Senior citizens' club				−1.7
Once or more per week	0.76 (0.52–1.12)	0.89 (0.58–1.36)	27 (30.7)	
Several times per month	0.77 (0.59–1.01)	0.76 (0.56–1.02)	58 (31.4)	
Several times per year	0.80 (0.65–1.00)	0.89 (0.70–1.14)	87 (31.1)	
Almost never	1.00	1.00	1,031 (34.8)	
Religious group or association				0.4
Once or more per week	0.99 (0.61–1.58)	0.87 (0.51–1.48)	18 (31.6)	
Several times per month	1.06 (0.71–1.58)	1.07 (0.68–1.68)	28 (34.6)	
Several times per year	1.34 (0.96–1.87)	1.31 (0.90–1.90)	47 (39.2)	
Almost never	1.00	1.00	1,110 (34.1)	
Sports group				7.5
2–3 times per week	1.90 (1.50–2.41)	1.31 (1.01–1.69)	115 (44.4)	
Once per week	1.73 (1.36–2.20)	1.20 (0.92–1.56)	104 (42.4)	
Several times per month	1.64 (1.25–2.16)	0.99 (0.74–1.34)	75 (41.0)	
Several times per year	1.54 (1.17–2.04)	1.02 (0.75–1.39)	69 (39.2)	
Almost never	1.00	1.00	840 (31.7)	
Neighborhood community association				14.5
Once or more per week	1.42 (0.99–2.02)	0.98 (0.65–1.47)	34 (32.4)	
Several times per month	1.63 (1.30–2.05)	0.93 (0.72–1.19)	100 (35.5)	
Several times per year	1.83 (1.60–2.08)	1.19 (1.02–1.39)	522 (41.4)	
Almost never	1.00	1.00	547 (29.3)	
Hobby club				16.8
2–3 times per week	1.98 (1.58–2.49)	1.36 (1.05–1.76)	122 (43.0)	
Once per week	2.06 (1.67–2.54)	1.39 (1.10–1.75)	157 (44.9)	
Several times per month	1.84 (1.54–2.20)	1.16 (0.95–1.42)	194 (38.8)	
Several times per year	2.13 (1.71–2.65)	1.41 (1.11–1.81)	140 (45.0)	
Almost never	1.00	1.00	590 (28.5)	

OR = odds ratio; CI = confidence interval.
[a]Odds ratio adjusted for sex, age, marital status, current medical history, activity of daily living, educational attainment, and annual equivalent income.
[b]Population-attributable fraction.
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participation in ≥1 social groups. Similarly, the PAFs for participation in sports groups, neighborhood community associations, and hobby groups were 7.5%, 14.5%, and 16.8%, respectively, for having ≥20 remaining teeth. Therefore, promoting and supporting opportunities for social participation, especially in sports groups, neighborhood community associations, or hobby clubs, as a public health intervention may contribute to an increase in the number of older people with ≥20 remaining teeth.

Our study has several limitations as well as strengths. First, the response rate was moderate (59.0%); hence, our results may have been affected by selection bias. Second, our research data were derived from self-reported questionnaires, raising issues of information bias regarding the true number of remaining teeth. However, self-reports have yielded reasonably valid estimates for the number of teeth in national epidemiological surveys in several prior studies [27,28]. In a study of 2,496 Japanese older people, the difference between the self-reported number of teeth and the clinically examined number of teeth was very small and insignificant according to the *t*-test, and the correlation between the 2 groups was very high (r = 0.93) [28]. Therefore, it is reasonable to assume that self-reported questionnaires can provide sufficiently reliable data about the number of remaining teeth. Third, our study was cross-sectional; therefore, it was not possible to generate any statements on causation. The present cross-sectional study could not exclude the possibility of reverse causation, in that people with good oral health tend to participate in social activities. Longitudinal studies or intervention studies are needed to examine the effects of social participation on dental health status. Lastly, our study participants were from one medium-sized municipality in Japan; hence, the generalizability of our results is limited. Caution should be exercised when interpreting our results, as it requires the somewhat strong assumption that the data we used for our analysis are generalizable to the entire population.

However, the population sample also could be considered a strength, as our data were less affected by geographic and cultural factors between municipalities, which provides some assurance of internal validity. The level of detail included in the social participation variable is another strength. Lastly, our data were reliable because all of the older residents in one city were recruited for our survey, and a large number of people participated.

Conclusion

Social participation was significantly and positively associated with better dental health status among older Japanese adults. Approximately one-third of the participants had ≥20 teeth, which may have been attributable to their participation in ≥1 social groups, though the present cross-sectional design could not exclude the possibility that people with good oral health tend to participate in social activities. In addition, our results indicate the possibility that participation in sports groups, neighborhood community associations, or hobby clubs in later life is protective of dental health beyond individual differences in demographic variables and social class indicators.

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Author Contributions

Conceived and designed the experiments: KT JA KK KO. Performed the experiments: KT KO. Analyzed the data: KT JA. Contributed reagents/materials/analysis tools: KT JA KO. Wrote the paper: KT JA KK.

References

1. Marmot M, Shipley M, Brunner E, Hemingway H (2001) Relative contribution of early life and adult socioeconomic factors to adult morbidity in the Whitehall II study. J Epidemiol Community Health 55: 301–307.
2. McMunn A, Breeze E, Goodman A, Nazroo J, Oldfield Z (2005) Social determinants of health in older age. In: Marmot M, Wilkinson RG, editors. Social determinants of health. New York: Oxford University Press. pp. 267–296.
3. World Health Organization (2002) Active Ageing: a Policy Framework. Geneva, Switzerland: WHO.
4. Lindström M, Hanson BS, Ostergren PO (2001) Socioeconomic differences in leisure-time physical activity: the role of social participation and social capital in shaping health related behaviour. Soc Sci Med 52: 441–451.
5. Lindström M, Malmö Shoulder-Neck Study Group (2006) Psychosocial work conditions, social participation and social capital: a causal pathway investigated in a longitudinal study. Soc Sci Med 62: 280–291.
6. Levasseur M, Richard L, Gauvin L, Raymond E (2010) Inventory and analysis of definitions of social participation found in the aging literature: proposed taxonomy of social activities. Soc Sci Med 71: 2141–2149.
7. Holt-Lunstad J, Smith TB, Layton JB (2010) Social relationships and mortality risk: a meta-analytic review. PLoS Med 27; 7: e1000316.
8. Chiao C, Weng LJ, Botticello AL (2011) Social participation reduces depressive symptoms among older adults: an 18-year longitudinal analysis in Taiwan. BMC Public Health 11: 292.
9. Hirai H, Kondo K, Ojima T, Murata C (2009) Examination of risk factors for onset of certification of long-term care insurance in community-dwelling older people: AGES project 3-year follow-up study [in Japanese]. Nihon Koshu Eisei Zasshi 56: 501–512.
10. Harpham T, Grant E, Thomas E (2002) Measuring social capital within health surveys: key issues. Health Policy Plan 17: 106–111.
11. Putnam RD (1993) Making democracy work: civic traditions in modern Italy. New Jersey: Princeton University Press.
12. Aida J, Kuriyama S, Ohmori-Matsuda K, Hozawa A, Osaka K, et al. (2011) The association between neighborhood social capital and self-reported dentate status in elderly Japanese - the Ohsaki Cohort 2006 Study. Community Dent Oral Epidemiol 39: 239–249.
13. Furuta M, Ekuni D, Takao S, Suzuki E, Morita M, et al. (2012) Social capital and self-rated oral health among young people. Community Dent Oral Epidemiol 40: 97–104.
14. Murayama H, Fujiwara Y, Kawachi I (2012) Social capital and health: a review of prospective multilevel studies. J Epidemiol 22: 179–187.
15. Kawachi I, Kennedy BP, Glass R (1999) Social capital and self-rated health: a contextual analysis. Am J Public Health 89: 1187–1193.
16. De Silva MJ, McKenzie K, Harpham T, Huttly S (2005) Social capital and mental illness: a systematic review. J Epidemiol Community Health 59: 619–627.
17. Aida J, Hanibuchi T, Nakade M, Hirai H, Osaka K, et al. (2009) The different effects of vertical social capital and horizontal social capital on dental status: a multilevel analysis. Soc Sci Med 69: 512–518.
18. Rodrigues SM, Oliveira AC, Vargas AM, Moreira AN, E Ferreira EF (2012) Implications of edentulism on quality of life among elderly. Int J Environ Res Public Health 9: 100–109.
19. Merchant AT, Pitiphat W, Ahmed B, Kawachi I, Joshipura K (2003) A prospective study of social support, anger expression and risk of periodontitis in men. J Am Dent Assoc 134: 1591–1596.
20. Cohen S (2004) Social relationships and health. Am Psychol 59: 676–684.
21. Christakis NA, Fowler JH (2008) The collective dynamics of smoking in a large social network. N Engl J Med 358: 2249–2258.
22. Peruzzo DC, Benatti BB, Ambrosano GM, Nogueira-Filho GR, Sallum EA, et al. (2007) A systematic review of stress and psychological factors as possible risk factors for periodontal disease. J Periodontol 78: 1491–1504.
23. Rothman KJ, Greenland S, Lash TL (2008) Modern epidemiology (3rd ed.). Philadelphia: Lippincott Williams & Wilkins. pp. 51–70.
24. Federation Dentaire Internationale (1982) Global goals for oral health in the year 2000. Int Dent J 32: 74–77.
25. Yoshihara A, Watanabe R, Nishimuta M, Hanada N, Miyazaki H (2005) The relationship between dietary intake and the number of teeth in elderly Japanese subjects. Gerodontology 22: 211–218.
26. Kawachi I, Berkman LF (2001) Social ties and mental health. J Urban Health 78: 458–467.
27. Pitiphat W, Garcia RI, Douglass CW, Joshipura KJ (2002) Validation of self-reported oral health measures. J Public Health Dent 62: 122–128.
28. Ando Y, Ikeda S, Yoshihara A (1997) The reliability of self-assessment of number of remaining teeth using questionnaires [in Japanese]. J Dent Health 47: 657–662.

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Individual- and community-level social gradients of edentulousness

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Individual- and community-level social gradients of edentulousness

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Abstract

Background

Community-level factors as well as individual-level factors affect individual health. To date, no studies 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 explanatory factors in this association.

Methods

We analyzed the data from the Japan Gerontological Evaluation Study (JAGES). In 2010–2012, 112,123 subjects aged 65 or older responded to the questionnaire survey (response rate = 66.3%). Multilevel logistic regression analysis was 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.

Results

Of 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 incomes were significantly associated with a lower risk of edentulousness (odds ratios [ORs] by 10,000 USD increments were 0.37 (95% confidence 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 clinics, 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 incomes were associated with 0.78 and 0.84 times lower odds of edentulousness, respectively. 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).

Conclusions

Individual- and community-level social inequalities in dental health were observed. Public health policies should account for social determinants of oral health when reducing oral health inequalities.

Keywords

Dental public health, Edentulous/edentulism, Income inequality, Gender differences, Multilevel analysis

Background

Severe tooth loss is the 36th most prevalent condition among 291 diseases and it caused a loss of 106 disability-adjusted life-years per 100,000 population [1]. Prevalence of severe tooth loss increases with age. Approximately 20% of the older population experienced severe 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 the onset of future co-morbidities such as dementia [4] and mortality [5].

Recent studies showed that the prevalence of severe tooth loss differed by socioeconomic group [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 [10,11]. The differences in social conditions create a stepwise gradient of health conditions between social groups [12,13]. 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 [14]. Reducing oral health inequalities is an urgent matter for both researchers and policymakers [15-17]. Furthermore, determining the factors that affect oral health inequalities is important for future public health interventions.

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 [7,8,18]. Because community factors potentially affect the health of all residents in an area, it is important to understand their effects on health. However, to the best of our knowledge, no study has examined both the individual- and community-level social gradients of edentulousness. Thus, the aims of the present study were: 1) to investigate the association between individual- and community-level incomes and edentulousness, 2) to determine the explanatory factors for 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 [6,19,20]. 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 [21]. Both income variables were used as continuous variables 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 other), and educational attainment (years of school education received (<6, 6–9, 10–12, >12 years, and other)) were used as individual-level socio-demographic covariates. Marital status [22-24] and educational attainment [25,26] were associated with general and oral health status. In addition, both variables in this study were associated with income level. Therefore we included these variables as covariates.

Community-level socio-demographic covariate

Density of dental clinics is a proxy for access to dental care in communities. A previous study in Japan indicated that density of dental clinics was an appropriate proxy for access to care [27]. Dental status is associated with access to dental care [27]. Density of dental clinics is likely to be higher in urban areas than rural areas [28]. Generally, urban areas are richer than rural areas [29]. Thus, we used density of dental clinics as a covariate of community-level income in this analysis. Density of dental clinics in each municipality in 2010 were obtained from the census data and used as the community-level variable [30].

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 explanatory factors in the association between individual- and community-level incomes and edentulousness, we built the models as follows. Model 1 tested the association between individual-and community-level incomes and edentulousness. Model 2 tested the association between income variables and edentulousness after adjusting for age, sex, and marital status. Model 3 added educational attainment into Model 2. Model 4 was the fully adjusted model, adding the community-level variable (density of dental clinics) into Model 3. To determine gender differences in the effect of both individual- and community-level incomes on dental health, interaction terms were included in the fully adjusted model. To evaluate the degrees of individual- and community-level variances in edentulousness, median odds ratios (ORs) were calculated [31]. 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 (Approval number: 10–05).

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 had significantly lower incomes and lived in communities with lower mean incomes ($p < 0.001$).

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	Married	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)	
	Other	313 (82.4)	67 (17.6)	
Educational attainment	<6ys	1,120 (61.70	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)	
	Other	413 (79.9)	104 (20.1)	
Continuous variables		Mean (SE)		
Density of dental clinics (per 10 thousand population)		4.45 (±0.837)	4.31 (±0.699)	$p < 0.001$[‡]
Individual income (10 thousand US dollars[*])		2.39 (±1.553)	1.95 (±1.467)	$p < 0.001$[‡]
Community income (10 thousand dollars[*])		3.18 (±0.297)	3.09 (±0.285)	$p < 0.001$[‡]

[†] p-value for chi-squared test.
[‡] p-value for *t*-test.
[*] 1 US Dollar = 100 Japanese Yen.

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 OR 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.

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

	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)
Fixed effect						
Individual-variables						
Individual income (10 thousand US dollars)	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 (1.94-2.47)	2.19 (1.93-2.48)
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)
Other			1.79 (1.41-2.28)	1.80 (1.42-2.28)	1.80 (1.42-2.28)	1.80 (1.42-2.29)
Community-variables						
Community income (10 thousand US dollars)	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 clinics (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 OR	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-variable (density of dental clinics).
Model 5,6: Model 4 + each interaction term.
*1 US Dollar = 100 Japanese Yen.

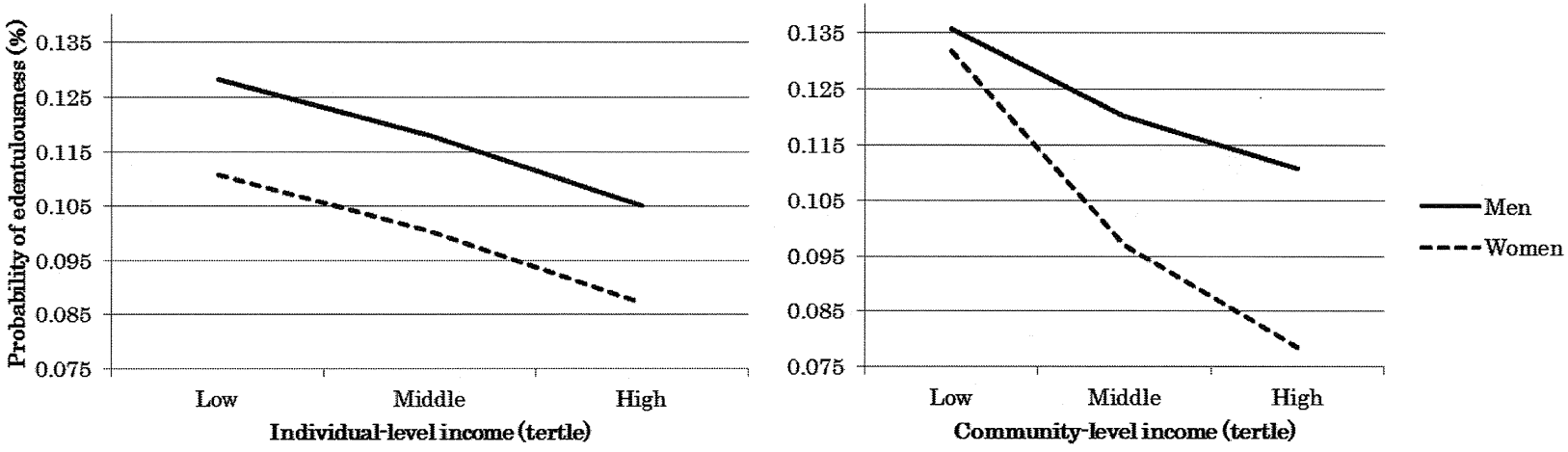

Figure. Gender difference in the association between individual- and community- level incomes and probability of edentulousness (N=78,405).