

## SYSTEMATIC REVIEW OPEN ACCESS

# Social Relationships and Tooth Loss in Adults Aged 60 Years and Older: A Systematic Review and Meta-Analysis

Eiko Yoshida-Kohno<sup>1,2</sup> | Kenji Fueki<sup>3</sup> | Amal A. Wanigatunga<sup>4,5</sup> | Thomas K. M. Cudjoe<sup>5,6</sup> | Jun Aida<sup>7</sup>

<sup>1</sup>Research Development Center, Institute of Science Tokyo, Tokyo, Japan | <sup>2</sup>Institute of Global Health Policy Research (iGHP), Bureau of International Health Cooperation, National Center for Global Health and Medicine, Tokyo, Japan | <sup>3</sup>Department of Masticatory Function and Health Science, Graduate School of Medical and Dental Sciences, Institute of Science Tokyo, Tokyo, Japan | <sup>4</sup>Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA | <sup>5</sup>Center on Aging and Health, Johns Hopkins University and Medical Institutions, Baltimore, Maryland, USA | <sup>6</sup>Division of Geriatric Medicine and Gerontology, Johns Hopkins School of Medicine, Baltimore, Maryland, USA | <sup>7</sup>Department of Dental Public Health, Graduate School of Medical and Dental Sciences, Institute of Science Tokyo, Tokyo, Japan

**Correspondence:** Eiko Yoshida-Kohno ([ekorin.rpro@tmd.ac.jp](mailto:ekorin.rpro@tmd.ac.jp))

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**Keywords:** older adults | social network | social support | systematic review | tooth loss

## ABSTRACT

**Objective:** To systematically assess current evidence on the extent to which social relationships are associated with tooth loss in adults aged 60 years and older.

**Methods:** A systematic literature search was conducted on PubMed, Embase, Web of Science, CINAHL and The Cochrane Library databases to identify relevant studies published from 1966 up to March 2024. Cross-sectional or cohort studies investigating the association between structural, functional and/or combined (structural and functional) components of social relationships and the number of remaining teeth or edentulism among community-dwelling or institutionalised older adults were included. Data were extracted on participants' and study characteristics, including study design, the type of measures used to assess social relationships (structural, functional, and combined), outcome measures and association estimates. The quality of the studies was assessed using the Newcastle-Ottawa Scale (NOS) for cohort studies and the adapted NOS for cross-sectional studies. The reported association between social relationships and the number of remaining teeth or edentulism was summarised using meta-analysis with robust variance estimation.

**Results:** Twenty studies were included in the review and 12 studies (125 553 participants) in the meta-analysis. Across the 12 studies, the average odds ratio (95% confidence interval) was 1.15 (1.01–1.32), indicating a 15% higher likelihood of having a lower number of teeth or edentulism for those with weaker social relationships. The GRADE certainty of the body of evidence was low.

**Conclusions:** Weak social relationships were associated with a lower number of teeth or edentulism in older adults. Our findings may inform potential public health approaches that target and modify social relationships to prevent and address older adults' oral diseases. Still, the directionality and the underlying mechanisms connecting social relationships and tooth loss need to be further explored by longitudinal studies with follow-up long enough for oral health outcomes or changes in social relationships to occur.

**Trial Registration:** Protocol Registration: PROSPERO (CRD42023417845)

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## 1 | Introduction

In the worldwide ageing population, social isolation and loneliness among older adults are recognised as growing public health challenges [1]. Social isolation is defined as the objective lack or a minimal number of social contacts and interactions with family members, friends or the wider community and results from a lifelong process [2, 3]. Loneliness is defined as a subjective negative feeling associated with a perceived lack of a wider social network or absence of a specific desired companion [4]. Older adults are more likely to experience many of the risk factors for social isolation and loneliness, including the death of loved ones, decreased mobility, retirement or changes in income [5]. Additionally, older adults are particularly vulnerable to the physical and mental impacts of social isolation and loneliness, with outcomes such as high blood pressure [6], decreased resistance to infection [7, 8], depression, cognitive decline [9] and a higher rate of mortality [6, 10]. Thus, social relationships are key to older adults' health and well-being [11]. The major components of social relationships include the degree of integration in social networks [12], the quantity and quality of aid and assistance provided as a function of social networks (i.e., received social support) and perceptions and assessments of the availability of social support (i.e., perceived social support) [13, 14]. The first component represents structural aspects, whereas the latter two represent functional aspects of social relationships [15]. The association between social relationships and health including oral health has been explained through the stress-buffering model hypothesising that social relationships may provide informational, emotional or tangible resources that moderate or buffer the deleterious influence of stressors on health, as well as the main effects model proposing that being part of a social network may encourage healthy behaviours and subsequently lead to protective health effects [16–19].

Studies with observational approaches have been conducted to investigate the association between social relationships and oral conditions in older adults [20–23], as with other health outcomes studies [24–26]. Across the studies, social relationships have been defined and measured in diverse ways. Additionally, the oral conditions (i.e., dental caries, periodontitis, tooth loss, and self-rated oral health) being studied are different and range widely. Synthesis of previous findings along with clarifications of measures of social relationships and oral conditions would allow for understanding which and to which degree oral conditions are influenced by distinct types of measures of social relationships. In addition, findings from evidence synthesis may play a critical and prominent role in planning strategies aimed at reducing oral diseases and as a basis for informing evidence-based practices.

The present study focuses on tooth loss as the outcome of interest since tooth loss is one of the main oral conditions with increasing prevalence with age and reflects the endpoint of a lifelong accumulation of oral diseases including dental caries and periodontitis [27]. Therefore, this study aimed to systematically review and synthesise the current evidence on the association between social relationships and tooth loss in older adults.

## 2 | Methods

This review was conducted according to the established guidelines [28–30]. The review protocol was registered after the pilot screening stage (PROSPERO CRD42023417845). The PRISMA 2020 Checklist [29] for this review is reported in Table S1.

### 2.1 | Search Strategy

An electronic literature search was conducted using five electronic databases (PubMed, Embase, CINAHL, The Cochrane Library and Web of Science) for English language studies published from 1966 up to December 2023. Updated searches for relevant studies were conducted until March 31, 2024. The search strategies are described in detail in Text S1, showing the oral health measures other than tooth loss that were also considered outcomes of interest. The reference lists of the retrieved studies were also examined to identify additional eligible studies.

### 2.2 | Inclusion Criteria

#### 2.2.1 | Population

Studies conducted on community-dwelling or institutionalised adults aged 60 years and older were included, relying on a general age threshold for older adults. Studies focusing on specific populations, such as people with psychological disorders, indigenous people and hospital inpatients, were excluded.

#### 2.2.2 | Exposure

Although previous epidemiological studies on social relationships have included a wide range of concepts such as participation, cohesion and social capital, structural (the degree of integration in social networks) and functional (received and perceived social support) components are consistently evaluated [15]. Thus, studies that assessed social relationships using structural, functional and/or combined (structural and functional) aspects were included. Search terms related to these aspects, including social networks, social participation, social support, social trust and social cohesion, were used.

#### 2.2.3 | Outcomes

Studies that evaluated the number of remaining teeth or tooth loss including edentulism were included.

### 2.3 | Study Selection, Data Extraction, and Quality Assessment

Cross-sectional or cohort studies (prospective or retrospective) were included in this review.

Titles and abstracts were examined to remove irrelevant studies by one reviewer (EYK) and the full texts of the potentially

relevant studies were retrieved. Two reviewers (EYK and KF) independently screened the full texts according to the eligibility criteria and made final decisions on study inclusion/exclusion. Subsequently, they independently extracted relevant data, including the study design, participant characteristics, exposures, measured outcomes, and association estimates from every study. The association estimates with the greatest contrast (i.e., between the highest and lowest levels of social relationships) were extracted. Extracted data were recorded in a web-based tool (Systematic Review Data Repository, SRDR+) [31].

The reviewers also independently assessed the quality of included studies using the Newcastle-Ottawa Scale (NOS) for cohort studies [32] and the adapted NOS for cross-sectional studies [33]. The NOS is structured into three domains through which bias might be introduced into the results of individual observational studies: (1) participant selection, (2) comparability of study groups and (3) ascertainment of outcome of interest. Individual studies were graded with 7 or more stars (low risk of bias), 4–6 stars (moderate risk of bias) and 0–3 stars (high risk of bias) [34].

## 2.4 | Data Synthesis and Analyses

Only studies that reported odds ratios (OR) and corresponding 95% confidence intervals (CIs) and controlled for possible confounding factors including participants' socio-economic factors were used for quantitative data synthesis. Some studies have reported multiple OR values within a study, using the same individuals at the same point or multiple points in time across different measures of social relationships. Thus, a meta-analysis with robust variance estimation, which handles dependence arising from multiple measures taken on the same individuals, was performed to synthesise the association estimates. Subsequently, a sensitivity analysis was conducted to check the robustness of the average association estimates to different values of the user-specified within-study effect size correlation [35, 36].

Heterogeneity among the observed association estimates was assessed using  $I^2$  statistic [37]. The possibility of publication bias or small study effects was assessed using a contour-enhanced funnel plot [38]. The certainty of the body of evidence was graded using the framework developed by the GRADE Working Group [39].

All analyses were performed using R Statistical Software (v4.3.1; R Core Team 2023) [40]. Specifically, a meta-analysis with robust variance estimation was conducted using the robumeta R package (v2.1) [41] and the funnel plot was created using the metafor R package (v4.4.0) [42]. The level of confidence was reported at 95%.

## 3 | Results

The search strategy returned 13098 studies. After full-text screening, 20 studies [23, 43–61] with a total number of 170 679

participants were included. The flowchart of the search process is shown in Figure 1. The characteristics and the quality of the included studies are summarised in Table S2.

### 3.1 | Characteristics of Included Studies

Of the 20 included studies, 15 (75%) were cross-sectional and 5 (25%) were cohort studies. Two cohort studies performed cross-sectional data analysis.

Sixteen studies (80%) were conducted in very highly developed countries (the human development index (HDI) [62]  $\geq 0.800$ ) (7 in Japan, 3 in the USA, 3 in Sweden and Norway, 1 in Denmark, 1 in the UK and 1 in Korea); 3 studies (15%) in a highly developed country (HDI 0.700–0.799) (China) and 1 study (5%) in a country with medium development (HDI 0.550–0.699) (India).

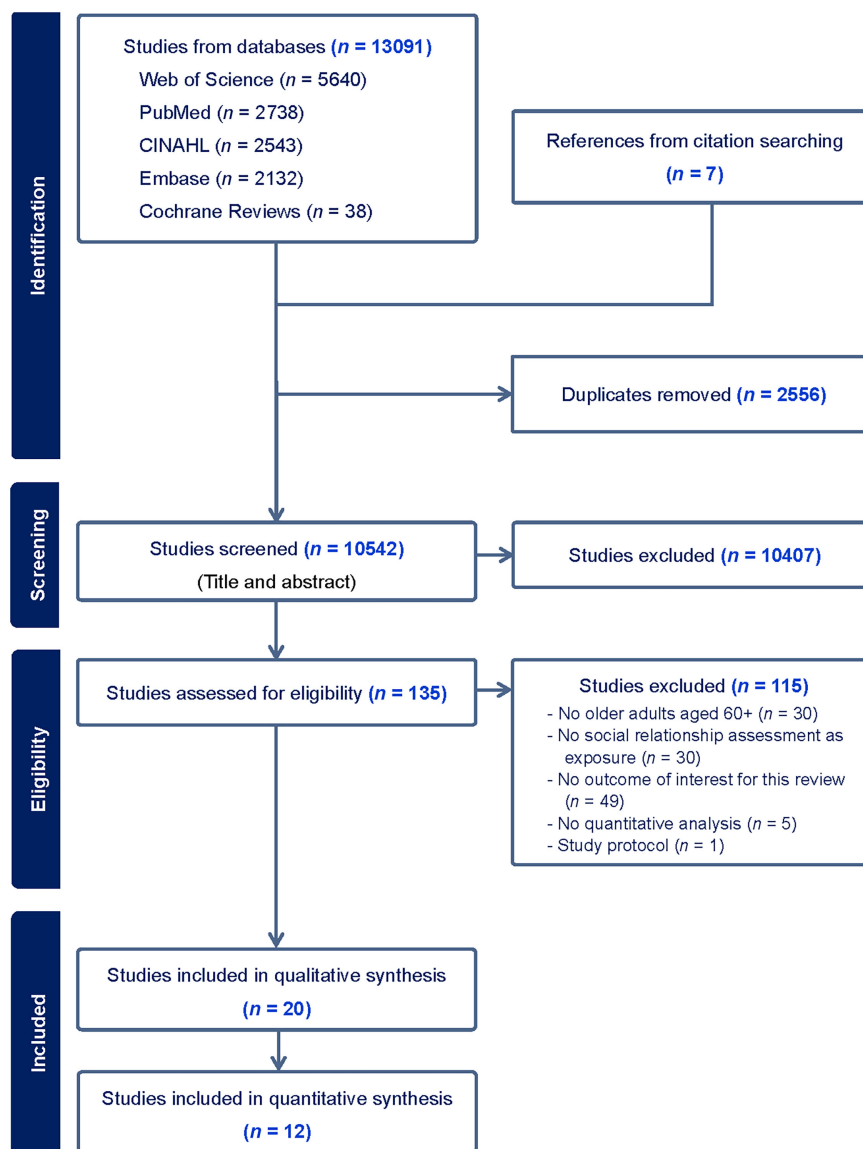
Nineteen studies (95%) were conducted among community-dwelling older adults and had no criteria to exclude individuals with certain comorbidities; 1 study (5%) among institutionalised older adults with criteria to exclude ones with obvious signs of cognitive impairment.

Twelve studies (60%) had data exclusive to structural measures of social relationships, 1 study (5%) exclusive to functional measures, 6 studies (30%) both structural and functional measures and 1 study (5%) both structural and combined measures. Based on the definitions of the types and subtypes of social relationships [15], perceptions of loneliness were coded as a functional measure. Seventeen studies (85%) assessed individual-level social relationships and three studies (15%) assessed both individual- and community-level social relationships. All the measures were assessed by interviewing participants or self-administered questionnaires. Table S2 provides the type and level of measures used to assess social relationships and the descriptions of exposure assessments.

Nine studies (45%) assessed the number of remaining teeth as an outcome of interest, 6 studies (30%) edentulism, 2 studies (10%) presence of missing teeth, 1 study (5%) both edentulism and the number of missing teeth and 2 studies (10%) loss of remaining teeth during the follow-up. The outcome measures were assessed by interviewing participants or self-administered questionnaires in 14 studies (70%, 10 cross-sectional and 4 cohort studies) and by clinical oral examinations in 6 studies (30%, 5 cross-sectional and 1 cohort studies).

A total of 89 association estimates were obtained across the included studies (61 ORs, 9 prevalence ratios, 7 regression coefficients, 8 mean differences and 4 proportions). Of these, 35 estimates (39%) found weak social relationships were significantly associated with having a lower number of teeth or edentulism, 1 estimate (1%) found the opposite association, and 53 estimates (60%) found no significant association.

Nineteen studies (95%) controlled for participants' socio-economic factors including educational and occupational background, income and race/ethnicity (16 used more than one



**FIGURE 1** | Search process (PRISMA flow diagram).

socio-economic factor; three only one); 1 study (5%) did not control for participants' socioeconomic factors.

Seventeen studies (85%) were deemed to be high quality (NOS  $\geq 7$ ), 2 studies (10%) moderate quality (4–6) and 1 study (5%) low quality ( $\leq 3$ ).

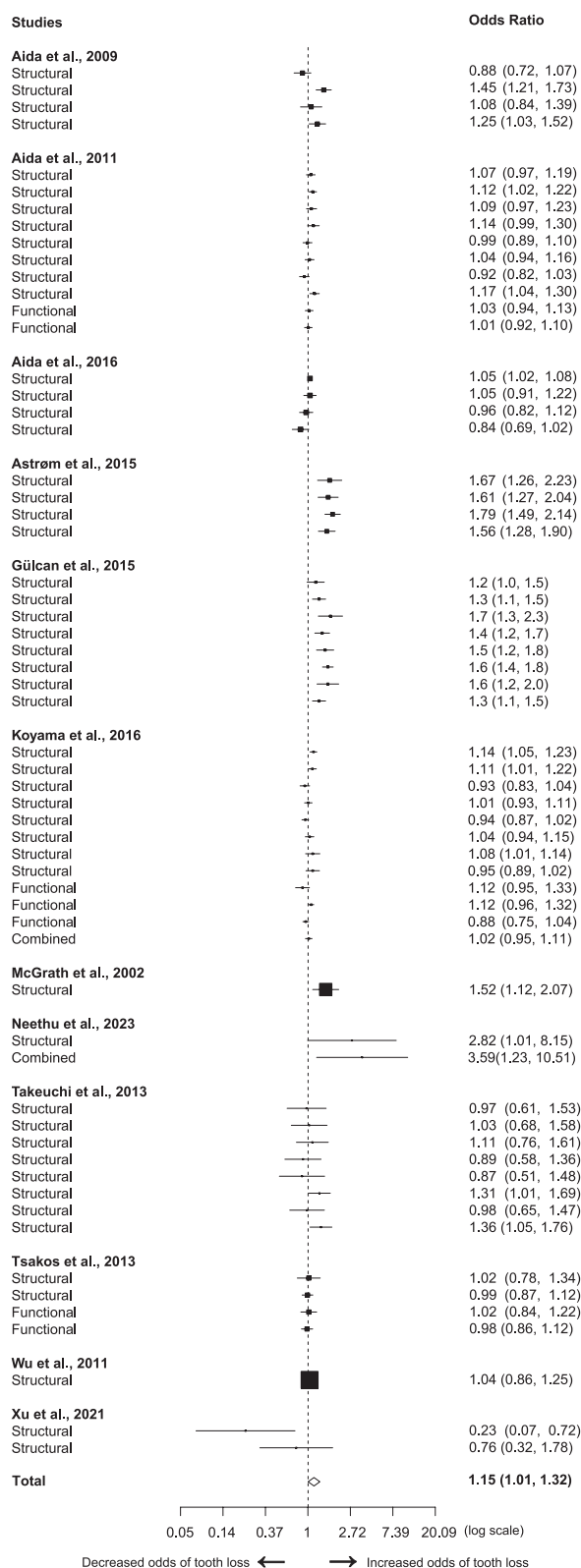
### 3.2 | Quantitative Data Synthesis

Meta-analysis with robust variance estimation was performed for 12 studies (125 553 participants) reporting 60 ORs together with corresponding 95% CIs [23, 43–45, 47, 51–53, 57–60]. The average association estimate was OR = 1.15 (95% CI = 1.01–1.32) (degrees of freedom = 9.16,  $p = 0.04$ ), which indicated a 15% higher likelihood of having a lower number of teeth or edentulism for those with weaker social relationships (Figure 2). The sensitivity analysis showed that the average association estimates were robust to different values of the assumed within-study correlation between effect sizes.

### 3.3 | Omnibus Evaluation

While heterogeneity among the observed ORs was found to be substantial ( $I^2 = 77.18\%$ ,  $\tau^2 = 0.03$ ) [37], subgroup analyses or meta-regression to explore the heterogeneity were not possible due to uneven distribution of potential covariates across the studies and a lack of a substantial number of studies (at least 40 studies) to conduct meta-regression with robust variance estimates [35, 63]. For these reasons, a visual inspection of scatter plots of the ORs against each of study-level possible covariates were conducted. Given the findings of previous studies [64, 65], participants' average age, the type of evaluation of social relationships (structural, functional, and combined), outcomes measures, methodology (design, quality) [66], and the HDI were considered possible covariates. As a result of visual inspection, the odds of having a lower number of teeth or edentulism in community-dwelling older adults with weak than strong social relationships appeared to be higher in countries with high than low HDI, as well as in younger than older age groups. Since only one of the included studies involved institutionalised older





**FIGURE 2** | Association between social relationships and tooth loss. Forest plot presents studies comparing the prevalence of a lower number of remaining teeth or edentulism in older adults with weak compared with strong social relationships. Point estimates of individual odds ratios are plotted as boxes with areas proportional to the weight assigned to that odds ratio and two-sided 95% confidence intervals are plotted along with each box. The average odds ratio from meta-analysis with robust variance estimation is shown at the bottom of the plot as a diamond with width equivalent to the confidence interval for the estimated association.

adults, no relevant observations could be made for the institutionalised (Figure S1).

The risk of publication bias or small study effects was not evident in the visual inspection for asymmetry of the funnel plot (Figure S2). Again, statistical analyses including Egger's regression intercept test [67] were impossible due to an insufficient number of studies (again, at least 40 studies are needed).

The grading of the certainty of a body of evidence involves consideration of the five domains that may decrease the level of certainty (risk of bias, inconsistency, indirectness of evidence, imprecision of the effect estimates and risk of publication bias) as well as the three domains that may increase confidence in the effect estimate (large effects, dose-response and opposing plausible residual bias and confounding) [39]. The grading approach found the evidence level to be low, with no downgrading and no upgrading performed.

## 4 | Discussion

To our knowledge, this is the first systematic review examining whether social relationships are associated with tooth loss among older adults. The quantitative data synthesis found weaker social relationships to be associated with a greater risk of having a lower number of remaining teeth or edentulism in adults over 60 years of age, although the estimated association was weak. Most studies included community-dwelling older adults, used cross-sectional data, involved heterogeneous exposure (i.e., structural, functional and combined (structural and functional) social relationships at individual and community levels) and outcome assessments (number of remaining teeth, edentulism) and were conducted in very highly developed countries. Although most findings were at low risk of bias, the certainty of the available evidence was graded as low mainly due to the majority of study being cross-sectional, the lack of detected large effects and/or dose-response relationships.

Poor oral health is common among older adults [68] and older adults often reported oral health-related concerns including oral pain, eating problems and oral discomfort [69]. However, reduced mobility and transportation difficulties with ageing are substantial barriers to performing oral hygiene practices and dental service availability or use [70]. In this context, older people with weak social relationships are likely to receive less tangible support to deal with the oral health problems, which leads to an accumulation of untreated dental conditions or a late-stage disease diagnosis, and thus a poor prognosis [19], as well as to psychological distress that may lower immune competence to oral bacteria [18] and bring about health-compromising behaviours such as tobacco use and the consumptions of sugar-rich comfort food and beverages [71]. Among institutionalised older adults, performing oral hygiene practices and visiting dentists are even more problematic than those in other settings, due to impairment in daily functioning [72] and fully depending on caretakers to organise oral (self) care [73]. Therefore, institutionalised older adults might be particularly vulnerable to developing poor oral health in a short period of time [74]. Additionally, given that older adults in institutionalised settings are basically

in need of tailored support in developing and maintaining their social relationships, an underlying explanation for the association in institutionalised older adults might be different from that in community-dwelling older adults.

Given a possible association between socio-economic status (SES) and social relationships [75], a cost barrier to dental care may be another explanation for the observed link. Treatment costs and restrictions in public funding for adult dental services add to the challenge of accessing care, especially for older adults experiencing poor social relationships and socio-economic conditions [76]. The consequent lower dental service use in older ages may also result in worse dental and/or oral conditions.

The findings of this review may partly reflect the reverse directional associations, that is, the effect of tooth loss on social relationships. Previous cross-sectional and cohort studies found that having a lower number of teeth or edentulism negatively affects social relationships among older adults [77–79]. The plausibility of this association has been explained mainly through the social roles of teeth, including smiling, speaking, eating and maintaining facial aesthetics [80]. Therefore, tooth loss would reduce or hinder the social roles involved with teeth, resulting in reduced social connectedness and participation in social activities. However, a cohort study examining bi-directional longitudinal associations between individuals' social relationships and oral health measures among adults aged 50 years and over suggested that the direction of the association from weak social relationships to poor oral health is more plausible than oral health as a determinant of social relationships [81]. In contrast, another bi-directional exploratory cohort study among adults aged 65+ found the opposite plausibility [82]. Still, there is a lack of evidence to identify which direction is dominant or whether both directions are equivalent. Future research needs to explore the mechanisms that link social relationships and oral health measures.

This review was conducted on observational studies mostly using cross-sectional data. While possible confounders, including participants' SES (e.g., educational and occupational background, income), demographics, and general conditions, were controlled in most of the cross-sectional studies, residual confounding may remain due to additional confounders that were not considered. Participants' SES in earlier life may explain part of the observed association since accumulating evidence suggests earlier-life socio-economic disadvantage is associated with both poor social relationships and tooth loss in later adulthood [83–85]. Applying graphical models such as causal-directed acyclic graphs would be useful to identify and control residual confounders [86] as well as to improve cross-sectional approaches. To understand the presented association, a need remains for further longitudinal studies with follow-up long enough for oral health outcomes to occur, in countries or areas with various degrees of development, and with methodological procedures allowing for examining dose–response relationships. To strengthen the evidence base, future research would need efforts to harmonise measures, assess social relationships and tooth loss and standardise methods for data analysis and reporting of effect size. Additionally, interventions to increase social relationships may also need to be studied to explore the impact, cost-effectiveness,

feasibility and sustainability on older adults' oral health and to understand how the interventions work in various contexts and social groups [87].

## 4.1 | Strengths and Limitations

The review covered the whole spectrum of social relationships and tooth loss conditions for the high number of participants and primarily included high-quality studies. Additionally, robust variance estimation was used in the meta-analysis, which allowed for the inclusion of dependent effect size estimates originating from the same study, that is, using this approach, it is not necessary to collect only one effect size estimate from potentially multiple per study. Thus, the findings of the review are likely to provide a comprehensive understanding of the association with precision of the estimate.

In a social determinants framework for oral diseases, social relationships are part of intermediary drivers, intervening between structural (e.g., socio-economic, political) and proximal (behavioural, biological) determinants [88]. Although oral health-care and clinical preventive approaches to address the proximal determinants have been primarily implemented, a need remains for integrated approaches targeting and modifying the intermediary drivers including social relationships, shared between oral diseases and other non-communicable diseases [19]. From perspectives of public health practice and policy, our findings may provide some insights into how to address older adults' oral diseases that disproportionately affect poorer and socio-economically disadvantaged groups in society, being linked to broader social determinants.

The review has several limitations. First, it was based on English language publications only. This language restriction might have introduced selection bias. Second, only the differences between the lowest and highest social relationships were assessed, which mostly does not reflect the “true” range of difference as well as does not allow estimating the gradient of difference [64]. Third, studies focusing on older adults with certain conditions including dementia and psychomotor disorders were excluded from the review because of their potential to modify the association between social relationships and tooth loss. Thus, the observed association cannot be directly applied to those populations, leaving a need for further research. Fourth, tooth loss status in older adults may well reflect their health behaviour including prior dental treatment history (i.e., when and where they received dental care and what dental treatment options were available or affordable to them at that time), cultural background (e.g., cultural context of sugars consumption behaviour), and health policy (e.g., policy on community water fluoridation) throughout life course. Thus, it should be noted that the association between social relationships and tooth loss may vary across countries, race/ethnicity and time periods studied. Also, oral health measures other than tooth loss, including oral hygiene status and dental attendance, still need to be studied as outcomes relevant to older adults' social relationships. Fifth, it was not possible to perform a meta-analysis for all the obtained association estimates because the transformation of different effect estimates was not allowed due to the lack of primary data. However, this would not significantly change the findings of quantitative synthesis since the precluded

data primarily indicated the direction of effect consistent with data included in the synthesis. Sixth, a substantial heterogeneity was found in the meta-analysis, but potential causes of the heterogeneity were not investigated with statistical means mainly due to a lack of sufficient number of studies. In terms of social relationships, structural, functional and combined measures were used for the evaluation. Given the structural and functional components are only moderately correlated, typically ranging between 0.20 and 0.30 of a correlation coefficient [12, 89] and each may influence health in different ways [13, 90], different components of social relationships may be a potential cause of the observed heterogeneity. Additionally, multilevel social relationships consisting of individual and community levels were included. Considering individual-level social relationships may mediate the association between community-level social relationships and oral health [44], the different levels of social relationships may act as another potential cause of the heterogeneity. It is presently unclear which aspect of social relationships is more associated with tooth loss. As for tooth loss status, edentulism and lower number of remaining teeth were used for the evaluation. Given that distinct conditions of tooth loss may be included especially when smaller number of missing teeth is involved, the mixture of tooth loss measures in the meta-analysis may also cause heterogeneity. Taken together, potential moderators of the association estimates still need to be explored. Seventh, statistical tests for funnel plot asymmetry were not implemented due to an insufficient number of studies included in the meta-analysis. Although the contour-enhanced funnel plot we used may aid visual interpretation of the asymmetry, a concern remains that it is inherently subjective [91]. Subsequent tests could add objective evidence on the presence of asymmetry, and if asymmetry had been detected, the possible sources (e.g., publication bias or small study effects, poor methodological quality) would have been discussed. Last, the certainty of the body of evidence was graded to be low. In the GRADE approach, a body of evidence from non-randomised studies of interventions including observational studies begins with a low-certainty rating and subsequently grading using the five domains lowering and the three domains raising the level of certainty applied. Assessments of each domain resulted in neither downgrading nor upgrading, which yielded a low rating for certainty of evidence. Since evidence levels based on observational studies are generally never identical to those from randomised trials due to the potential bias induced by the lack of randomisation (i.e., confounding and selection bias) [39], the outcomes of this study require careful interpretation.

## 5 | Conclusions

In conclusion, there is an association between weaker social relationships and a greater risk of tooth loss among older adults. Although the estimated association is weak, our findings strengthen the current evidence that social relationships are a factor that prevents tooth loss among older adults. In addition, the findings informed potential public health approaches that target and modify social relationships to address older adults' oral diseases. Since social relationships are major contributors to older adults' health and well-being, the efforts to improve social relationships may be shared in a broader health context. On the other hand, the available evidence highlighted a need for further studies to address a gap in evidence of the direction of

the association between tooth loss to weak social relationships and the underlying mechanisms connecting social relationships and tooth loss.

## Author Contributions

Study concept and design: Eiko Yoshida-Kohno and Jun Aida. Data acquisition, analysis and interpretation: Eiko Yoshida-Kohno, Kenji Fueki, Amal A. Wanigatunga, Thomas K. M. Cudjoe and Jun Aida. Manuscript writing: Eiko Yoshida-Kohno. Reviewing and Critical revisions: Eiko Yoshida-Kohno, Kenji Fueki, Amal A. Wanigatunga, Thomas K.M. Cudjoe and Jun Aida.

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## Conflicts of Interest

The authors declare no conflicts of interest.

## Data Availability Statement

The data supporting this study's findings are available in the [Supporting Information](#) of this article and from the corresponding author upon reasonable request.

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## Supporting Information

Additional supporting information can be found online in the Supporting Information section.