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The relationship between social network, social support and periodontal disease among older Americans.

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3 **The relationship between social network, social support and periodontal disease among**
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5 **older Americans.**
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For Peer Review

Abstract

Aim: The objectives of this study were to examine the relationship between social network, social support and periodontal disease among older **American** adults and to test whether social network and support mediates socioeconomic inequality in periodontal disease.

Materials and Methods: Data pertaining to participants aged 60 years and over from the National Health and Nutrition Examination Survey 2001-2004 was used. Periodontal disease variables were extent loss of periodontal attachment $\geq 3\text{mm}$, and moderate periodontitis. Social support and networks were indicated by need for emotional support, number of close friends and marital status.

Results: Widowed **and those with lowest number of friends had higher rates of the extent of loss of periodontal attachment (1.27,95%CI:1.03,1.58) and (1.22,95%CI:1.03,1.45), respectively.** Marital status and number of friends were not significantly associated with moderate periodontitis after adjusting for behavioural factors. The need for more emotional support was not related to periodontal disease in this analysis. Social networks and support had no impact on socioeconomic inequality in periodontal disease.

Conclusion: Certain aspects of social network, namely being widowed and having fewer friends were linked to the extent of loss of periodontal attachment **but not to the definition of moderate periodontitis, in older adults.**

Clinical Relevance

Scientific Rationale for Study: Lower levels of social network and support are related to morbidity and mortality, and poorer oral health. This relationship was not adequately examined in relation to periodontal health of older adults.

Principal Findings: Older adults in the USA who reported being widowed or having least number of friends had significantly higher levels of loss of periodontal attachment. Moderate periodontitis was not significantly related to social network and support in models adjusting for socioeconomic and behavioural factors for this age group.

Practical Implications: The findings highlight the importance of social relationships in the periodontal health of older adults.

Introduction

Lower levels of social network, support and isolation are related to various aspects of physical and mental disease, and to rates of mortality (Berkman & Kawachi 2000; Stansfeld 2006). There is an inverse relationship between higher levels of social network and support on the one hand and morbidity, coronary heart disease and cause specific mortality rates, on the other hand (Ruberman et al 1984; Orth-Gomer & Johnson 1987; Berkman et al 1992; Kawachi et al 1996; Eng et al 2002; Stansfeld 2006; Hoppmann & Gerstorf 2009; Mead et al 2010). Several theories have been postulated about the mechanism linking social network and support to health and mortality (Berkman 1985; Stansfeld 2006). They include direct financial and physical support to engage in health enhancing behaviours and to access care, gaining information from the social network pertaining to innovative health promoting behaviours and health hazards. Furthermore, social and emotional support could help mitigate the consequences of stressful events and coping with diseases, risk factors, and the negative effect of social isolation (Berkman 1985; Kawachi et al 1996) through alterations in neuroendocrine and immunological control systems (Brunner and Marmot 2006). As there are common pathways affecting general and oral health, (Sheiham & Nicolau 2005; Sabbah et al 2008 Borrell & Crawford 2010), some dental studies have examined the relationship between social network and support and other societal characteristics with oral health in children and adolescents (Hanson et al 1994; Pattussi et al 2007; 2008; Aida et al 2008; 2009) and in adults (McGrath & Bedi 2002; Merchant et al 2003; Monteiro da Silva 1996). One study examined the relationship between social networks and periodontitis among male health professionals in the USA and found that individuals having friends and who participated in social activities were less likely to have periodontitis (Merchant et al 2003). Another study reported an association between social isolation and periodontitis (Monteiro da

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3 Silva 1996). However, these two studies on the relationship between periodontitis and social
4 network and support were either conducted in a specific occupational group or on a relatively
5 small sample.
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12 While social support and networks were suggested to mediate the socioeconomic inequalities
13 in general health (Stansfeld 2006), no study has examined this possible role of social support
14 and networks in relation to oral health. Therefore, we set out to examine the relationship
15 between social network and support and periodontal disease in a nationally representative
16 sample of American older adults, and to assess whether social network and support mediated
17 the known socioeconomic inequality in periodontal diseases (Stansfeld 2006).
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33 We postulated that higher levels of social network and support were inversely related to
34 periodontal disease among older American adults. Considering the different mechanisms
35 through which social network and support influences health (Berkman 1985; Kawachi et al
36 1996), our second hypothesis was that social network and support mediates the relationship
37 between socioeconomic position and periodontal disease in older adults. The objectives of
38 the study were to test: (1) the relationship between three markers of social network and
39 support (Cohen et al 2000), namely number of close friends, need for emotional support and
40 marital status, with periodontal disease; (2) whether social network and support mediated the
41 socioeconomic disparities in periodontal disease, in a national representative sample of
42 Americans aged 60 years and older.
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Materials and Methods

Data were on participants aged 60 years and over who participated in the National Health and Nutrition Examination Survey (NHANES) 2001 to 2004. NHANES 2001-2004 collected information on a nationally representative sample in each year using a stratified, multistage design to obtain a representative probability sample of the civilian noninstitutionalized population of the United States (CDC, 2005).. The survey collected data on individual characteristics such as gender, age, race/ ethnicity, education, income and marital status. The interviewer also asked questions about selected behaviours, including smoking and dental visits. Furthermore, the survey included questions on social network and support providing data on emotional, material, and network (the number of members in a network) support (CDC, 2005). The questions were selected from the Yale Health and Aging Study and the Social Network Index – Alameda County Study (Ruberman et al 1984).

The MEC examination included a detailed oral examination (Dye et al 2007b). Participation in the oral health component was limited to age groups considered most critical for monitoring oral health (13 years and older for periodontal examination). Information was also obtained from the home interview covering assessments on perceived oral health status (CDC, 2005). The NHANES periodontal examination protocol was based upon the (NIDCR) criteria with minor modifications (Dye et al 2007b).

Periodontal disease variables:

Periodontal assessments in NHANES 2001-2004 were made at three facial sites (mesio-, disto-, and mid-facial) on each fully erupted permanent tooth, except third molars, in two

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3 randomly selected quadrants (one maxillary and one mandibular). Detailed information on
4 the NHANES dental examinations for the survey periods are published elsewhere (Drury et al
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6 1996; Dye et al 2007a;b). Periodontal data were used from the surveys 2001-2002 and 2003-
7
8 2004 for consistency in the number of sites diagnosed for periodontal disease. Two variables
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10 were created: (1) extent of loss of periodontal attachment of 3mm+ (expressed as the
11
12 percentage of affected sites), and (2) moderate periodontitis was defined by the presence of 2
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14 or more inter-proximal sites with loss of attachment of 4mm or more (not on same tooth), or
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16 2 or more inter-proximal sites with pocket depth 5mm or more (not on same tooth) (Page &
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18 Eke 2007).
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25 ***Social network and support variables:***

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28 Three variables indicating social network and support were used. Whether the participants
29
30 needed more emotional help during the past year was used as a measure of social support.
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32 Number of close friends, and marital status were used as indicators of social networks. These
33
34 three markers of social network and support have been repeatedly used in medical (Manzoli
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36 et al 2007; Hoppmann & Gerstorf 2009; Mead et al 2010), and dental studies (Marcenes &
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38 Sheiham 1996; Merchant et al 2003; Aida et al 2009). The need for emotional support was a
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40 dichotomous variable (yes, no), the number of close friends was categorised into tertiles.
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42 Marital status was grouped to indicate whether the participants were (1) married or live with
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44 a partner, (2) widowed, (3) divorced, separated or single.
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50 ***Behavioural variables***

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53 These included smoking and dental visits. Smoking indicates whether the person is a current
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55 smoker, a former smoker who smoked at least 100 cigarettes, or never smoked. Dental visit
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57 indicates whether the participant visited a dentist at least once within the past 2 years.
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Socio-demographic variables:

These included age (continuous variable), gender, and race/ ethnicity (White, African Americans, Mexican Americans, other Hispanic and other ethnicities). Income was indicated by family poverty-income ratio, which is the ratio between house hold income and poverty threshold, and is used to account for inflation throughout the years of the survey. Poverty income ratio was categorised into quartiles. Education reflects whether the participants had less than high school diploma, high school, or more than high school.

Statistical analysis

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First we assessed the distribution of all explanatory variables by periodontal status (moderate periodontitis). A series of regression models were conducted for both periodontal disease variables alternatively adjusting for markers of social network and support. The first model was adjusted for gender, age and race/ ethnicity, the second model additionally adjusted for education, income, number of teeth and diabetes, the third model additionally adjusted for dental visits and smoking. The sequence of adjustment is based on the hypothesis that social network and support influence health through an impact on health-related behaviours (Berkman 1985). **This method was used in medical research to account for direct and indirect effect of explanatory factors (van Oort et al. 2005).** Logistic regression was employed in the analysis pertaining to moderate periodontitis, and negative binomial regression in the analysis pertaining to extent of loss of periodontal attachment.

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Other studies have indicated that men benefit more than women from social network and support (Berkman 1985; Berkman & Kawachi 2000), hence we tested for interaction between

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2
3 social support and networks variables and gender. We also tested interaction between social
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5 networks and each of age, smoking and dental visits. To demonstrate that the relationship
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7 between social support and networks with periodontal disease operates via a behavioural
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9 pathway, we also examined the association between the three markers of social support and
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11 networks with each of dental visits and smoking, **adjusting for sex and age.**
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19 Regression models were conducted to measure the variation in income and education
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21 disparities in periodontal disease and the impact of adjusting for social support and network
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23 on the socioeconomic disparities in periodontal disease. The first model adjusted for age,
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25 gender, race/ ethnicity, number of teeth, diabetes, smoking status and dental visits, in addition
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27 to income and education. The second model additionally adjusted for marital status, number
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29 of friends and needing more emotional support, in order to assess whether the relationship
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31 between income and education and periodontal disease is attenuated after adjustment for
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33 social networks and support. A four year weight variable based on the 2-years mobile
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35 examination weight was created and used to adjust for the complexity of the survey. Stata
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37 survey command was used throughout the analysis.
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47 **Results:**

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49 The analysis was conducted for 1632 older adults aged 60 years and over who had complete
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51 social network and support and periodontal disease data in NHANES 2001-2004. There was
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53 no significant difference in periodontal disease between the 1632 individuals included in the
54
55 analysis and the 134 individuals excluded for having incomplete data in this age group. The
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57 mean age was 69.7 years. The prevalence of moderate periodontitis was 23.1% and 17.1%
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3 among participants aged 60 to 70 years and 71 and older, respectively. Married and
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5 cohabiting individuals had lower prevalence of moderate periodontitis (18.6%) than widowed
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7 (23.7%), and divorced (19.1%). Similarly, individuals with the highest number of friends had
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9 the lowest prevalence of periodontitis (Table 1).
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15 The mean age of widowed individuals (74.8 years) was higher than that of married and
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17 cohabiting (68.9 years) and divorced and single (67.5). On the other hand, more women were
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19 widowed (37.5%) than men (10.8%). The mean age across tertiles of number of close friends
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21 was 69.7, 69.8 and 70.5 years in the highest, middle and lowest friend group.
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27 There was a relationship between the three markers of social support and networks, and
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29 smoking and dental visits. Smoking was highest among divorced (22%) than widowed (8%)
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31 and married (7%). Similarly, 13% of participants with least number of friends were
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33 smokers, compared to 8% among participants with more friends. Individuals who needed
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35 emotional support had higher prevalence of smoking (10%) than those who did not need
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37 emotional support (9%). Married participants reported more visits to a dentist (82%) than
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39 widowed (73%) and divorced (72%). Individuals with highest number of friends reported
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41 more dental visits (83%) than those in the middle (81%) and lowest (70%) friend groups.
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44 Participants who did not need emotional support reported more dental visits (80%) than those
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46 who needed emotional support (71%).
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53 **Widowed and divorced participants were more likely to be a current or former smoker**
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55 **compared to married participants, with odds ratios of 1.58 (95%CI 1.16, 2.14) and 1.79**
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57 **(95%CI 1.41, 2.27), respectively in a regression model adjusting for sex and age. Widowed**
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59 **and divorced individuals were also less likely to visit a dentist with odds ratios of 0.50**
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3 (95%CI 0.38, 0.65), and 0.62 (95%CI 0.49, 0.78) respectively. On the other hand,
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5 participants in the middle and lowest number of friends groups had insignificant odds ratios
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7 of 1.07 (95%CI 0.86, 1.34) and 1.12 (95%CI 0.92, 1.39) respectively for being current or
8
9 former smokers in a regression model adjusting for sex and age. Participants with the lowest
10
11 number of friends were significantly less likely to visit a dentist than those with highest
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13 number of friends with odds ratios of 0.52 (95%CI 0.42, 0.64). The odds ratios for the
14
15 associations between need for support and being a current or former smoker, and dental visits
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17 were not significant with odds ratios of 0.93 (95%CI 0.74, 1.16) and 0.82 (95%CI 0.63, 1.05),
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19 respectively.
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27 Table 2 shows the association between the three markers of social network and support
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29 (marital status, needing more emotional support and number of friends) with extent of loss of
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31 periodontal attachment of 3mm or more and case definition of moderate periodontitis (Page
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33 & Eke 2007). Widowed and divorced had higher levels of loss of periodontal attachment
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35 than married persons, with rate ratios 1.60 (CI 1.27, 2.01) and 1.33 (CI 1.09, 1.63),
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37 respectively. After adjusting for income, education, smoking and dental visits, widowed still
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39 had significantly higher levels of loss of periodontal attachment (Table 2). Widowed
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41 individuals were significantly more likely to have moderate periodontitis than married
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43 individuals (OR 1.65, CI 1.09, 2.05). However, this relationship lost significance after
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45 adjusting for income, education, smoking and dental visits. Participants with the least
46
47 number of friends had significantly higher levels of loss of periodontal attachment than those
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49 with the highest number of friends. This relationship remained significant even after
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51 adjusting for socioeconomic and behavioural factors (rate ratio 1.22, CI 1.03, 1.45) (Table 2).
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53 Similarly, persons who had the lowest number of friends were significantly more likely to
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55 have moderate periodontitis (OR 1.53, CI 1.15, 2.04). The relationship was eliminated after
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3 adjusting for behaviours. Needing more emotional support did not appear to have an
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5 association with periodontitis or the extent of loss of periodontal attachment (Table 2).
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10 While there was clear income gradients in moderate periodontitis, education did not seem to
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12 have a great impact on moderate periodontitis for this age group (Table 3). Overall, social
13
14 network and support had a very modest impact on the association between income and
15
16 education, and moderate periodontitis. Individuals in the lowest income quartile had odds
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18 ratios of 2.17 (CI 1.26, 3.73) for having moderate periodontitis. After adjusting for social
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20 network and support, this odds ratio hardly changed (Table 3). On the other hand,
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22 participants in the lowest education group had higher levels of loss of periodontal attachment
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24 (rate ratio 1.42, CI 1.15, 1.76). After adjusting for social network and support the
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26 relationship was slightly attenuated and remained significant (Table 3). There was no
27
28 interaction between social network variables with neither of age, gender, smoking nor dental
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30 visits.
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39 Discussion

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41 Marital status and numbers of friends were significantly associated with two indicators of
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43 periodontal disease measuring case definition and severity of the disease among older
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45 Americans aged 60 years and over. Considering the postulated mechanism for the
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47 relationship between social network, support and oral health through health behaviours
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49 (Berkman 1985), the aforementioned relationships lost significance after adjustment for
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51 behaviours, with the exception of the relationships between being widowed and having
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53 lowest number of friends with extent of loss of periodontal attachments. Furthermore, social
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55 network and support variables did not seem to have an impact on socioeconomic disparities
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60 in periodontal disease.

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6 In the current study we used number of friends, needing more emotional support and marital
7 status to indicate social network and support (Cohen et al 2000). Numbers of friends and the
8 need for emotional support have both been frequently used as markers of social network and
9 support (Ruberman et al 1984; Orth-Gomer & Johnson 1987; Berkman et al 1992; Kawachi
10 et al 1996; Eng et al 2002; Stansfeld 2006; Hoppmann & Gerstorf 2009; Mead et al 2010;
11 Mead et al 2010). Furthermore, two dental studies found that having a greater number of
12 friends was inversely related to periodontal disease (Monteiro da Silva 1996; Merchant et al
13 2003). The current study supports these findings by demonstrating them in a nationally
14 representative sample of American older adults. On the other hand, the need for emotional
15 support was not associated with periodontal disease in this study.
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32 Marital status was an important determinant of health and mortality, especially among older
33 adults (Manzoli et al 2007; Hoppmann & Gerstorf 2009). Additionally, Marcenes and
34 Sheiham (1996) demonstrated the importance of the quality of marriage for oral health. In
35 the current study, marital status appeared to be the most important social networks factor in
36 relation to periodontal diseases among older adults with being widowed maintaining its
37 significant relationship with the extent of loss of periodontal attachment even after adjusting
38 for smoking and dental visits. It is worth noting that while widowed persons were generally
39 older than the rest of the sample, which would imply that the observed relationship with
40 periodontal disease is due to the accumulative effect of age. However, there was no
41 interaction between marital status and age. Furthermore, the majority of widowed were
42 women, who generally have lower levels of periodontal disease than men.
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3 This is a cross-sectional study which cannot provide evidence on causal inferences. Being
4
5 widowed had a stronger relationship with periodontal disease than being divorced or single.
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8 As the death of a spouse is very likely to be a stressful life event, this finding is consistent
9
10 with psychological pathways affecting periodontal disease by reducing host resistance and
11
12 the ability to cope with stressors (Sheiham & Nicolau 2005). Being divorced may also be a
13
14 stressful life event, though in this age group it is reasonable to speculate that becoming
15
16 widowed was probably a relatively more recent life event than being divorced, and this may
17
18 partly contribute to the stronger association with current periodontal status. On the other
19
20 hand, periodontitis is a progressive, cumulative disease; hence the importance of more recent
21
22 stressful events is questionable. The relatively stronger relationship between being widowed
23
24 and periodontal disease could also be attributed to the older age of widowed participants,
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26 potentially indicating the possibility of residual confounding by age; however the analysis
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28 adjusted for the effect of age group.
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36 In this study we also examined income and education gradients in periodontal disease and the
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38 impact of controlling for social network and support on the aforementioned relationship.
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40 There were income and education gradients in periodontal disease. However social network
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42 and support appeared to have no impact on the social gradients in periodontal disease.
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44 Stansfeld (2006) found that social network and support had a limited effect on the social
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46 gradients in general health. Other studies have indicated that men benefit more than women
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48 from social network and support (Berkman 1985; Berkman & Kawachi 2000), in this study
49
50 there was no interaction between gender and social network and support.
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57 The effect of social network and support on health was postulated to occur through four
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59 pathways (Berkman 1985; Kawachi et al 1996): first, an instrumental support, for example
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3 financial support; second, informational support where individuals acquire knowledge about
4 health promoting habits and hazards to health from their social network; third, emotional
5 support which help individuals to cope with the disease and with health hazards; fourth,
6 through an influence on host resistance. It is highly likely that similar pathways affect
7 periodontal disease in older adults (Sheiham and Nicolau 2005). For example, social network
8 and support could influence oral health through a change in behaviours (McGrath & Bedi
9 2002), or by buffering the negative effect of stressful events on periodontal disease (Sheiham
10 and Nicolau 2005). These pathways linking social network and support and oral health could
11 not be tested in this study due to data limitations.
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27 This study demonstrated that social networks, indicated by number of friends and marital
28 status, were significantly related to severity of loss of attachment in a nationally
29 representative sample of older Americans aged 60 years and over. The importance of certain
30 aspects of social networks, namely being widowed, and having few friends were further
31 demonstrated as such individuals remained more likely to have greater levels of loss of
32 periodontal attachment even after adjusting for behavioural determinants of periodontitis such
33 as smoking and dental visits. Social network and support appeared to have no impact on the
34 social gradients in periodontal disease in this age group.
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48 The current study has the advantages of using a nationally representative sample of **American**
49 older adults and assessing the impact of social network and support on the social gradients in
50 periodontitis. However, considering the cross-sectional nature of the study, no causal
51 association could be concluded from this study. Additionally, the dataset lacked a number of
52 important behavioural factors, such as tooth-brushing, which could have influenced the
53 results. Furthermore, the variable on the need for emotional support is a crude measure of
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3 social support as it indicates individuals' perception of the need for emotional support. Others
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5 have used a question asking whether an individual received any emotional support (Berkman
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7 & Kawachi 2000). In this study, it is possible that even individuals who reported the need
8
9 for emotional support still received some support.
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15 Social networks indicated by number of friends and marital status was significantly related to
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17 the extent of loss of periodontal attachment, but not the definition of moderate periodontitis,
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19 after adjusting for socioeconomic and behavioural factors in a nationally representative
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21 sample of older Americans aged 60 years and over. Social network and support appeared to
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23 have no impact on the social gradients in periodontal disease in this age group.
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Table 1: Mean extent of loss of periodontal attachment and percentage of moderate periodontitis within groups of explanatory variables among older Americans (n=1632)

Explanatory factors (N)		Percentage with moderate periodontitis (95%CI)	Mean extent of loss of periodontal attachment (95%CI)
Gender	Males (832)	24.6% (21.3, 28.3)	0.24 (0.21, 0.26)
	Females (800)	15.7% (13.5, 18.2)	0.16 (0.14, 0.17)
Age group	60-70 years (884)	17.1% (14.2, 20.4)	0.17 (0.15, 0.19)
	71 and over (748)	23.1% (20.4, 26.1)	0.22 (0.20, 0.25)
Race/ethnicity	White Americans (948)	17.5% (15.2, 20.0)	0.18 (0.16, 0.20)
	African Americans (252)	29.9% (24.7, 35.6)	0.25 (0.22, 0.28)
	Mexican Americans (353)	31.6% (24.3, 40.0)	0.25 (0.20, 0.29)
	Other Hispanic (40)	37.2% (22.7, 54.3)	0.30 (0.23, 0.37)
	Other ethnicities (39)	21.8% (11.0, 38.8)	0.21 (0.13, 0.29)
Education	More than high school (701)	16.0% (13.2, 19.2)	0.16 (0.14, 0.17)
	High school (384)	18.8% (15.2, 23.0)	0.18 (0.16, 0.21)
	Less than high school (547)	30.2% (24.9, 36.0)	0.29 (0.25, 0.33)
Poverty-income ratio	Highest quartile (410)	14.8% (11.7, 18.6)	0.15 (0.13, 0.16)
	Second highest (407)	16.5% (13.2, 20.4)	0.18 (0.15, 0.20)
	Second lowest (406)	25.6% (20.9, 30.9)	0.23 (0.20, 0.26)
	Lowest quartile (409)	34.7% (27.7, 42.4)	0.32 (0.28, 0.36)
Marital status	Married/ cohabiting (1056)	18.6% (16.2, 21.2)	0.18 (0.16, 0.20)
	Widowed (341)	23.7% (18.9, 29.4)	0.23 (0.19, 0.26)
	Divorced, separated, single (253)	19.1% (14.0, 25.4)	0.22 (0.18, 0.25)
Number of close friends	Highest tertile (621)	16.2% (13.7, 19.1)	0.16 (0.15, 0.18)
	Middle tertile (519)	19.4% (16.7, 22.4)	0.19 (0.17, 0.21)
	Lowest tertile (492)	26.2% (21.9, 31.1)	0.25 (0.22, 0.28)
Need more emotional help	Yes (235)	18.5% (12.9, 25.9)	0.20 (0.16, 0.24)
	No (1397)	19.9% (17.6, 22.3)	0.19 (0.18, 0.21)
Dental visits	Within past 2 years (1197)	17.4% (15.1, 20.1)	0.17 (0.15, 0.18)
	Longer than 2 years (435)	28.2% (23.8, 33.2)	0.29 (0.26, 0.32)
Smoking	Current smoker (168)	34.8% (27.1, 43.5)	0.37 (0.32, 0.42)
	Former smoker (656)	22.9% (19.9, 26.3)	0.21 (0.18, 0.23)
	Never smoked (808)	14.3% (12.0, 17.0)	0.15 (0.13, 0.17)
diabetes	Yes (274)	21.9% (16.8, 28.2)	0.23 (0.19, 0.27)
	No (1358)	19.3% (17.5, 21.3)	0.19 (0.17, 0.20)

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Table 2: Association between social network and support indicators and two measures of periodontal disease among Americans aged 60 years and over (n=1632) (NHANES 2001-2004)

		Marital status (Reference group: married)		Need more emotional support	Number of friends (Reference group: highest Tertile)	
		widowed	Divorced/ separated		Middle Tertile	Lowest Tertile
Rate ratio for extent loss of attachment	Model 1	1.60 ^{***} (1.27, 2.01)	1.33 ^{**} (1.09, 1.63)	0.98 ^{NS} (0.74, 1.30)	1.05 ^{NS} (0.88, 1.26)	1.43 ^{***} (1.21, 1.68)
	Model 2	1.33 ^{**} (1.09, 1.63)	1.14 ^{NS} (0.90, 1.44)	0.86 ^{NS} (0.69, 1.07)	1.02 ^{NS} (0.85, 1.22)	1.23 [*] (1.05, 1.46)
	Model 3	1.27 [*] (1.03, 1.58)	1.07 ^{NS} (0.86, 1.34)	0.87 ^{NS} (0.72, 1.06)	0.99 ^{NS} (0.83, 1.19)	1.22 [*] (1.03, 1.45)
Odds ratio for moderate periodontitis	Model 1	1.65 [*] (1.09, 2.50)	1.07 ^{NS} (0.70, 1.61)	0.86 ^{NS} (0.51, 1.44)	1.19 ^{NS} (0.93, 1.53)	1.53 ^{**} (1.15, 2.04)
	Model 2	1.36 ^{NS} (0.88, 2.10)	0.88 ^{NS} (0.56, 1.37)	0.73 ^{NS} (0.45, 1.20)	1.14 ^{NS} (0.87, 1.78)	1.32 ^{NS} (0.97, 1.78)
	Model 3	1.28 ^{NS} (0.82, 2.00)	0.80 ^{NS} (0.52, 1.24)	0.76 ^{NS} (0.46, 1.25)	1.09 ^{NS} (0.84, 1.40)	1.29 ^{NS} (0.95, 1.77)

Model 1 adjusted for age, gender and race/ ethnicity, in addition to the variables of social network/ support. Model 2 additionally adjusted for income, education, diabetes and number of teeth. Model 3 additionally adjusted for smoking status (current, former smoker, never-smoker) and dental visits.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ^{NS} insignificant

Table 3: Income and education gradients in periodontal disease for Americans aged 60 years and over (n=1632) (NHANES 2001-2004)

		Education (Reference group: > high school)		Income (quartiles of poverty-income ratio, reference group: highest quartile)		
		High school	< high school	2 nd highest quartile	2 nd lowest quartile	Lowest quartile
Rate ratios for extent loss of attachment	Model 1	1.16 ^{NS} (0.94, 1.42)	1.42 ^{**} (1.15, 1.76)	1.05 ^{NS} (0.86, 1.29)	1.49 ^{**} (1.19, 1.87)	1.58 ^{**} (1.23, 2.04)
	Model 2	1.11 ^{NS} (0.89, 1.38)	1.38 ^{**} (1.12, 1.70)	1.03 ^{NS} (0.84, 1.27)	1.44 ^{**} (1.15, 1.79)	1.52 ^{**} (1.18, 1.96)
Odds ratio for moderate periodontitis	Model 1	1.18 ^{NS} (0.87, 1.62)	1.58 [*] (1.03, 2.44)	1.10 ^{NS} (0.76, 1.59)	1.80 ^{**} (1.22, 2.67)	2.17 ^{**} (1.26, 3.73)
	Model 2	1.13 ^{NS} (0.82, 1.55)	1.51 ^{NS} (0.97, 2.37)	1.10 ^{NS} (0.76, 1.59)	1.76 ^{**} (1.18, 2.64)	2.19 ^{**} (1.25, 3.84)

Model 1 adjusted for age, gender, race/ ethnicity, number of teeth, diabetes, smoking status (current, former smoker, never-smoker) and dental visits, in addition to income and education. Model 2 additionally adjusted for marital status, number of friends and needing more emotional support.

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ^{NS} insignificant