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Association between sense of coherence and oral clinical conditions in adults and the elderly: systematic review and meta-analysis

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Objective: This study systematically reviews the evidence on the relationship between sense of coherence (SOC) and oral clinical conditions in adults and elderly people. ***Methods***: PubMed, Scopus, Web of Science, Latin American and Caribbean Literature in Health Sciences - Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), Brazilian Dentistry Bibliography - Bibliografia Brasileira de Odontologia (BBO), Cochrane Library and grey literature were searched. Observational studies involving adults and elderly people that evaluated SOC with a valid instrument and investigated oral clinical measurements as outcomes were included. Two review authors independently assessed the studies for inclusion and extracted data. The quality of studies was assessed using the Downs and Black checklist. Meta-analysis used the random-effect inverse-variance method to obtain pooled odds ratios (OR) and 95% Confidence Intervals (CI) for each oral clinical condition. ***Results***: From a total of 872 identified studies, ten observational cross-sectional and one longitudinal study were included. Nine studies were judged of medium or high risk of bias. Meta-analyses showed that adults and elderly people with higher SOC were less likely to present dental caries (OR 0.84; 95%CI = 0.73-0.96), periodontal disease (OR 0.58; 95%CI = 0.30-0.85), gingivitis (OR 0.54; 95%CI = 0.18-0.90) or dental biofilm (OR 0.65; 95%CI = 0.43-0.86). *Conclusions*: Current evidence suggests that better SOC is positively related to better oral clinical status in adults and elderly people. Longitudinal and intervention studies are needed to confirm these findings.

Keywords*: Adults, Oral Health, Systematic Review, Sense of Coherence*

Introduction

The salutogenic theory proposed by Aaron Antonovsky (1979) emerged to challenge the pathogenic approach and the dichotomous concept of health with it's focus on the mechanisms leading to health. According to the salutogenic theory, the health/disease process must be understood as a continuum, which has implications for health promotion (Antonovsky, 1979).

The central construct of salutogenesis is sense of coherence [SOC], which is a protective psychosocial factor to cope with stressors, and consequently a significant facilitating factor for achieving and maintaining health. Individuals with strong SOC are more able to handle stress inherent to human existence, through the development of three important skills: understanding (cognitive component), management/management ability (instrumental component) and meaning (motivational component) (Antonovsky, 1987; Nammontri *et al*., 2012).

SOC is developed throughout life, especially during childhood and adolescence, and possibly becomes stable in adulthood. It is a stress-resisting resource shaped through social and cultural life experiences (Antonovsky, 1996; Eriksson and Lindström, 2005). SOC can be measured using a 29-item questionnaire developed by Antonovsky or the 13-item SOC questionnaire abbreviated version (Antonovsky, 1987). The questionnaire is valid, reliable, and cross-culturally applicable (Eriksson and Lindström, 2005; Lindström, 2018).

Oral health problems can affect the social and psychological well-being of individuals and impact on their quality of life (Eriksson and Mittelmark, 2017). Recent evidence suggests that high SOC is associated with better oral health and higher levels of oral health-related quality of life (OHRQoL) (Gomes *et al*., 2018; Machado *et al*., 2017; Reddy *et al*., 2016). Self-reported oral health measurements, such as OHRQoL, may not reflect the individual's oral clinical status, as their predictors, including sociodemographic factors, may differ. Thus, it is necessary to investigate the possible relationship between SOC and oral clinical indicators, such as dental caries, periodontal disease, mucosal lesions, dental biofilm, tooth loss, among others. A recent systematic review associated SOC with dental caries across different age groups (Torres *et al*., 2019). Children and adolescents with mothers with a lower SOC were more likely to have dental caries. Similarly, lower SOC was related to a higher probability of dental caries in adolescents. The relationship between SOC and oral health behaviours was investigated in another systematic review (Eyasi *et al*., 2015). The findings suggest a significant association between higher SOC and higher frequency of toothbrushing. In addition, individuals with higher SOC were more likely to have regular dental check-up appointments.

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Previous studies suggest the influence of SOC on oral clinical measures. Higher SOC was associated with better periodontal status in adults (Reddy *et al*., 2016) and lower periodontal attachment loss in adolescents (Shilpa *et al*., 2016). Studies involving elderly people have shown the relationship of higher SOC with keeping more teeth (Davoglio *et al*., 2016; Dewake *et al*., 2016) and lower dental prosthetic treatment need (Davoglio *et al*., 2016).

To date, there is no consensus regarding the influence of SOC on oral clinical conditions. Furthermore, the possible relationship between SOC and oral health in adults and elderly people has not been addressed in a systematic review. Understanding the relationship between SOC and health conditions in specific population groups can contribute to the development of promising health promotion strategies (Eriksson and Lindström, 2005; Lindström, 2018; Nammontri *et al*., 2012). This study aimed to review, systematically, current evidence on the association between SOC and oral clinical conditions in adults and elderly people.

Methods

This study followed the meta-analysis of observational studies in epidemiology [MOOSE] recommendations (Stroup *et al*., 2000). The protocol was registered on the International Prospective Register of Systematic Reviews database (PROSPERO), registration number CRD42018103396.

The acronym "PECO" (Moola *et al*., 2015) was adopted to examine the following question: "Does SOC influence the oral clinical conditions of adults [18 to 64 years old] and elderly people [65 years old or more]?", considering "Population" [P] – adults and elderly people; "Exposure" [E] – SOC, "Comparison" [C] - people with low SOC, and "Outcome" [O] - oral clinical conditions.

Studies were searched in the following electronic databases: PubMed, Scopus, Web of Science, Latin American and Caribbean Literature in Health Sciences - *Literatura Latino-Americana e do Caribe em Ciências da Saúde* [LILACS], Brazilian Dentistry Bibliography - *Bibliografia Brasileira de Odontologia* [BBO], and Cochrane Library. There were no language or publication date restrictions. The grey literature was explored based on the Coordination for the Improvement of Higher Education Personnel - *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* [CAPES] theses databases, abstracts from the annual conferences of the International Association for Dental Research [IADR] and Google Scholar. The reference lists of eligible studies were also screened to identify additional studies.

The search strategy (Appendix 1) included Medical Subject Headings [MeSH] terms and free descriptors related to the salutogenic theory and oral clinical measures. The themes were combined using the Boolean operators "AND" and "OR". All searches were performed between June and July 2021. References were managed using EndNote Basic software [Thomson Reuters, New York, NY, USA]. Each search strategy was adapted according to the specificities of each database.

Observational studies involving only adult individuals [18 to 64 years old] and elderly people [65 years old or older] assessing SOC through valid scales and at least one oral clinical condition were included. Studies that evaluated self-reported oral health outcomes but did not assess oral clinical conditions were excluded. Pilot studies, intervention studies, literature reviews, case reports and case series were also excluded.

After removing duplicates, articles were selected independently by two authors (BMC and MCLG) according to their titles and abstracts. Full texts were read when the title and abstract did not provide sufficient information to make a clear decision about eligibility. Disagreements between the two reviewers in selecting the papers were resolved by consensus after discussion with a third reviewer (LMW) to reach full agreement. Standardized forms were used to extract the following information: author/year, country, study design, age of participants, number of participants and proportion of male subjects), setting, SOC scale, oral clinical condition, statistical analyses and results. The Kappa coefficient of selecting studies between the two authors was 0.82.

The methodological quality of the studies was assessed using the Downs and Black (1998) checklist, as recommended in the Centre for Reviews and Disseminations guidelines (2009). Quality was assessed independently by the same authors (BMC and MCLG). Any disagreement was discussed with a third author (JSR) and the consensus was reached by discussion.

The Downs and Black (1998) tool consists of 27 items, divided into five domains: reporting (10 items), external validity (3 items), bias (7 items), confounding (6 items) and power (1 item). Each item scores 0 or 1, except the item related to the "report" domain in which three options are used (score from 0 to 2). High quality studies could receive a maximum of 28 points according to the original tool. In this study, the checklist was adapted and the 10 specific items applicable to intervention studies were not considered. Thus, cohort studies could achieve a maximum of 18 points. Four further items applicable to cohort studies were not used for cross-sectional studies that could achieve a maximum of 14 points. The higher the score obtained, the better the methodological quality of the study.

Risk of bias was also assessed according to an adapted version of the Cochrane collaboration tool (Higgins *et al*., 2011), with the inclusion of the four main domains of the Downs and Black checklist: reporting, external validity, internal validity (bias) and internal validity (confounding).

Risk of bias was analyzed and reported according to the four domains using signs to represent the possible occurrence bias, as presented in previous systematic reviews (Da Rosa *et al*., 2020; Rocha *et al*., 2018). A domain was considered have low risk of bias when all items met the proposed criteria. Unclear risk of bias was assigned when it was not possible to assess the criterion. Finally, the domain was considered to have high risk of bias when the criterion was not met.

The meta-analyses were grouped by oral clinical condition. The random-effect inverse-variance method was used to pool estimates by combining effect size (odds ratios [OR]) and 95% Confidence Intervals (CI) from cross-sectional studies where data could be extracted. Data were transformed to convert continuous effect size measurements, including mean differences, into standardized effect size OR using the reported means, standard deviations, and sample sizes. Further information about data transformation is available elsewhere (Lipsey and Wilson, 2001). Cochran's Q test was used to assess

statistical heterogeneity between studies. The I^2 test was employed to measure the proportion of variance between studies due to heterogeneity. I^2 results ≥ 0.75 were considered to show high heterogeneity (Higgins *et al*., 2003). All analyses were carried out using STATA version 16 (Stata Corp, TX, USA). A 5% significance level was set for all analyses. Sensitivity analysis was performed on meta-analyses including more than two studies that presented I^2 greater than 40% and studies with high risk of bias (Deeks *et al.*, 2019). The sensitivity analysis was to verify whether the pooled estimate was influenced by studies with high risk of bias.

Results

Initially 872 studies were identified (Figure 1). Fifteen studies were selected after screening the titles and abstracts. Four studies were excluded thereafter. One article did not meet the inclusion criteria since no oral clinical condition was assessed (Machado *et al*., 2017). Three other articles (Bernabé *et al*., 2010, 2012; Kanhai *et al*., 2014) were derived from the same study and analyzed as a single study. The characteristics of the 11 selected studies are reported in Table 1.

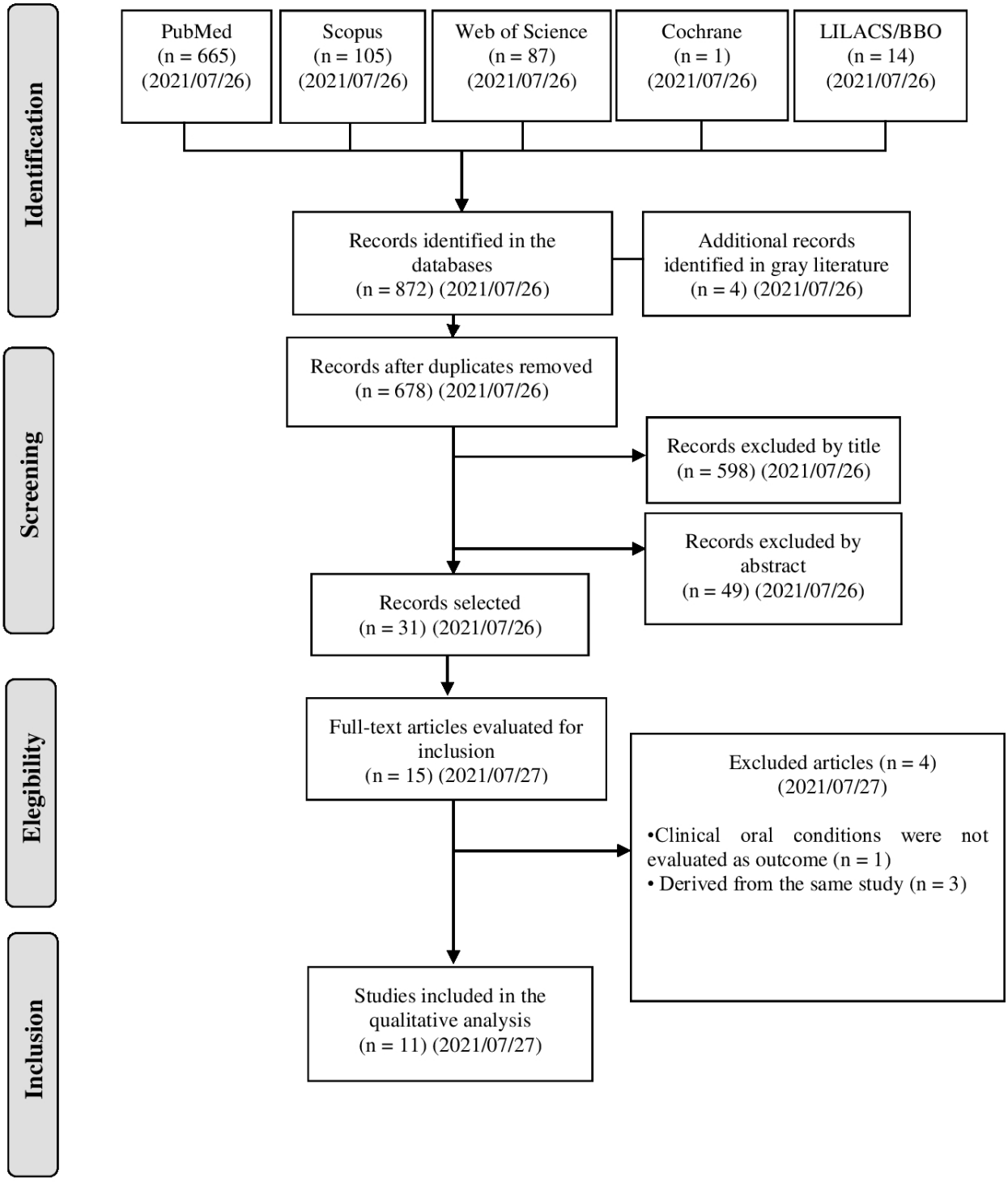

Figure 1. Flowchart from literature search to inclusion of studies. LILACS, Caribbean Latin American Literature in Health Sciences; BBO, Brazilian Bibliography of Dentistry.

Table 1. Summary of the included studies.

Author	*Country*	*Study design*	*Age, years Mean (SD)*	*No. participants (% male)*	*Setting*	*SOC measure*	*Assessed health condition*	*Statistics/ Adjustments*
Ahmed et al., 2018	India	Cross-sectional	Range: 51-55	120 (100)	Transport corporation	SOC-13	Oral hygiene index, caries, periodontal condition and mucosal lesions.	NR
Bernabé et al., 2010/ Bernabé et al., 2012/ Kanhai et al., 2013	Finland	Cross-sectional / Cohort/ Cohort	Mean (SD): 49.6 (12.8)/48.6 (11.9)/47.6 (11.5)	5401 (46.9)/994 (45)/848 (45)	Residence of participants in the "Health 2000 Survey"	SOC-13	Number of teeth, caries and extension of periodontal pockets/ Caries/Periodontal pocket depth.	NR/Yes/Yes
Cyrino et al., 2016	Brazil	Cross-sectional	Range: 18-60 Mean (SD): 37.4 (12.1)	276 (73.2)	Corporation employees	SOC-13	Probing depth, clinical attachment, bleeding on probing, plaque and gingival index.	Yes
Da Silva e Vettore, 2016	Brazil	Cross-sectional	>25 Mean (SD): 37.5 (7.2)	190 (0)	Public school	SOC-13	DMF-T.	Yes
Davoglio et al., 2016	Brazil	Cross-sectional	Age group: 50-74 Mean (SD) 60.2 (7.5)	720 (42.2)	Health District	SOC-13	Number of teeth, caries, prosthesis need.	Yes
Dewake et al., 2017	Japan	Cross-sectional	Mean (SD): 80.4 (6.5)	53 (32)	Elderly care service	SOC-13	Number of teeth present and use of dental prosthesis.	NR
Lindmark et al., 2011	Sweden	Cross-sectional	Age groups: 20, 30, 40, 50, 60, 70, and 80	519 (31)	County Government Board	SOC-13	Dental caries, filled surfaces, calculus and periodontal health.	Yes
Neves et al., 2013	Brazil	Cross-sectional	Age range: 18-66	100 (32)	Family Health Unit	SOC-13	Plaque and gingival bleeding after periodontal.	Yes
Possebon et al., 2017	Brazil	Cross-sectional	Age group: ≥ 60	164 (26.2)	Family Health Unit	SOC-29	Use and need for dental prosthesis, no. teeth present.	Yes
Reddy et al., 2016	India	Cross-sectional	Mean (SD): 38.5 (2.8)	780 (34.5)	Research and teaching institution	SOC-13	Periodontal index and insertion loss.	NR
Wennström et al., 2013	Sweden	Cross-sectional	Age group: 38 and 50	493 (0)	Hospital	SOC-13	No. teeth present, DMF-T.	Yes

Note: SD, standard deviation; NR, not reported; SOC, sense of coherence; DMF-T, decayed, missing, and filled teeth index.

Of the 11 studies, one was longitudinal (Bernabé *et al*., 2012/Kanhai *et al*., 2014) and 10 were cross-sectional. Five studies were carried out in Brazil (Cyrino *et al*., 2016; Da Silva and Vettore, 2016; Davoglio *et al*., 2016; Neves *et al*., 2013; Possebon *et al*., 2017), one in Finland (Bernabé *et al*., 2010, 2012/Kanhai *et al*., 2014), two in India (Ahmed *et al*., 2018; Reddy *et al*., 2016), two in Sweden (Lindmark *et al*., 2011; Wennström *et al*., 2013), one in Japan (Dewake *et al*., 2017).

The age of the participants ranged from 18 to 80 years. Five studies assessed only adults (Ahmed *et al*., 2018; Bernabé *et al*., 2010, 2012/Kanhai *et al*., 2014; Da Silva and Vettore, 2016; Reddy *et al*., 2016; Wennström *et al*., 2013), two studies included only elderly people (Dewake *et al*., 2017; Possebon *et al*., 2017), and the remaining four analyzed both age groups (Cyrino *et al*., 2016; Davoglio *et al*., 2016; Lindmark *et al*., 2011; Neves *et al*., 2013).

The settings of studies varied. Three recruited participants in healthcare units (Davoglio *et al*., 2016; Neves *et al*., 2013; Possebon *et al*., 2017). One included predominantly male workers from a bus drivers' cooperative (Ahmed *et al*., 2018). Other settings were a public school in Brazil (Da Silva and Vettore, 2016) and a teaching and research institution in India (Reddy *et al*., 2016).

The number of study participants ranged from 53 elderly people in Japan (Dewake *et al*., 2017) to more than 800 individuals (Bernabé *et al*., 2010, 2012/Kanhai *et al*., 2014). Of the 11 studies, one article (Possebon *et al*., 2017) used Antonovsky's (1987) original 29-item questionnaire (SOC-29). The remaining studies assessed SOC using SOC-13. The studies used different thresholds to categorise the participants into different levels of SOC.

The number of teeth was the most investigated oral clinical condition (Table 2). Seven studies analyzed the relationship between SOC and number of teeth (Bernabé *et al*., 2010, 2012/Kanhai *et al*., 2014; Cyrino *et al*., 2016; Davoglio *et a*l., 2016; Dewake *et al*., 2017; Lindmark *et al*., 2011; Possebon *et al*., 2017; Wennström et al., 2013). Dental caries was assessed in six studies (Ahmed *et al.,* 2018; Bernabé *et al*., 2010, 2012; Da Silva and Vettore, 2016; Davoglio *et al*., 2016; Lindmark *et al*., 2011; Wennström *et al*., 2013). Dental caries was assessed using the DMF-T index in five studies (Ahmed *et al*., 2018; Da Silva and Vettore, 2016; Davoglio *et al*., 2016; Lindmark *et al*., 2011; Wennström *et al*., 2013). Dental caries was registered if there was evidence of a caries lesion clearly extending into dentine on any coronal or root surface in one study (Bernabé *et al*., 2010, 2012). Different periodontal clinical parameters were investigated in six studies (Ahmed *et al*., 2018; Bernabé *et al*., 2010, 2012/Kanhai *et al*., 2014; Cyrino *et al*., 2016; Lindmark *et al*., 2011; Neves *et al*., 2013; Reddy *et al*., 2016). Periodontal attachment loss was the periodontal measure in four studies (Ahmed *et al*., 2018; Reddy *et al*., 2016; Bernabé *et al*., 2010, 2012/Kanhai *et al*., 2014; Lindmark *et al*., 2011). Dental biofilm and gingivitis were investigated in three studies (Cyrino *et al*., 2016; Lindmark *et al*., 2011; Neves *et al*., 2013). The relationship between SOC and need for dental prosthesis was assessed in two studies (Davoglio *et al*., 2016; Possebon *et al*., 2017). Only one study evaluated the use of dental prosthesis (Dewake *et al.*, 2017), and another study assessed the presence of mucosal lesions (Ahmed *et al*., 2018).

Table 2. Summary of data extracted from 11 included studies.

Author	*Parameters SOC*	*SOC X Oral clinical condition*
Ahmed et al., 2018	Low: 20-50 Moderate: 51-70 High: 71-88	+ SOC, - caries index. + SOC, - periodontal disease. + SOC, - loss of attachment. + SOC, zero oral mucosal lesions.
Bernabé et al., 2010/ Bernabé et al., 2012/ Kanhai et al., 2013	Based on the SOC score in: Weak (1 SD below the meancentred) Moderate (meancentred) Strong (1 SD above the mean-centred) High and Low Mean (SD): 5.5 (0.8)	+ SOC, + number of teeth present; + SOC, - caries index. + SOC, - periodontal disease. + SOC, - caries index / There was no association between SOC and the change in the number of teeth with periodontal pockets over four years.
Cyrino et al., 2016	Low: 24-46 Moderate: 47-51 High: 52-65	There was no association between SOC and gingivitis, periodontitis, clinical attachment level, pocket depth and plaque index.
Da Silva e Vettore, 2016	Alto: > mean Low: < mean Mean: 48 (30-63)	- SOC, + caries index, + dental pain.
Davoglio et al., 2016	Weak: < mean Strong: ≥ mean Mean: 69	+ SOC, - need for dental prostheses. + SOC, + number of teeth present.
Dewake et al., 2017	Mean (SD): 57 (13,.9)	+ SOC, + number of teeth present, + nutrition, - care need. There was no association with the use of dental prosthesis.
Neves et al., 2013	Categorized in quartiles: 26-38 39-44 45-50 51-61	There was no association between bleeding sites and plaque index with SOC.
Possebon et al., 2017	Mean (SD): 151.2 (21.0)	+ SOC, + self-assessed oral health, + number of teeth present. - SOC, - self-assessed oral health. There was no association with the need to use a dental prosthesis.
Reddy et al., 2016	Mean (SD): 48.2 (10.4)	+ SOC, - periodontal index (0 = health, 1 = bleeding). + SOC, - loss of attachment.
Wennström et al., 2013	Score ranges from 13-91. +Score, +SOC	- SOC, + number of missing teeth. There was no association between SOC and caries and filled surfaces.

Note: SOC, sense of coherence; SD, standard deviation; + Higher; - Lower.

Five of the seven studies that investigated the relationship between SOC and number of teeth associated higher SOC with having more teeth (Bernabé *et al*., 2010; Davoglio *et al*., 2016; Dewake *et al*., 2017; Possebon *et al*., 2017; Wennström *et al*., 2013). Highest SOC was inversely associated with number of teeth in one study (Possebo *et al*., 2017). One study showed an inverse relationship between dental caries and SOC (Bernabé *et al*., 2010, 2012). Da Silva and Vettore (2016) concluded that SOC was not associated with dental caries. The former moderated the relationship between dental caries and dental pain in women. One study found an association between higher SOC and better periodontal condition (Reddy *et al*., 2016). However, a prospective study did report the influence of SOC on the number of teeth with periodontal pockets over a four-year follow-up (Kanhai *et al*., 2014). Another report associated SOC with lower levels of dental biofilm (Lindmark *et al*., 2011). Davoglio et al. (2016) concluded that strong SOC was associated with lower needs of dental prosthesis. The same was not demonstrated by Possebon et al. (2017).

Risk of bias across studies

The quality and risk of bias assessments found only one longitudinal (Bernabé *et al*., 2010, 2012/Kanhai *et al*., 2014) and one cross-sectional study (Lindmark *et al*., 2011) to have low risk of bias (Figure 2). Six studies were judged to be of moderate quality (Cyrino *et al*., 2016; Da Silva and Vettore, 2016, Davoglio *et al*., 2016; Neves *et al*., 2013; Possebon *et al*., 2017; Wennström *et al*., 2013). Of those, three received 13 points and three received 11 points. Most studies failed to demonstrate internal validity. The domains Report and External validity were considered unclear in four studies. High risk of bias was assigned to three studies due to lack of adequate adjustment for confounding in the analyses (Ahmed *et al*., 2018; Dewake *et al*., 2017; Reddy *et al*., 2016).

Articles included	Risk of bias assessment[2]				Final judgment	Total score[3]
	Report	External validity	Internal validity (bias)	Internal validity (confunding)		
Bernabé *et al*., 2010/Bernabé *et al*., 2012/Kanhai *et al*., 2013[1]	+	+	+	+	+	18
Lindmark *et al*., 2011	+	+	+	+	+	14
Cyrino *et al*., 2016	+	+	?	+	?	13
Neves *et al*., 2013	+	+	?	+	?	13
Possebon *et al*., 2017	+	+	?	+	?	13
Da Silva e Vettore, 2016	+	?	?	+	?	11
Davoglio *et al*., 2016	+	?	?	+	?	11
Wennström *et al*., 2013	?	+	?	+	?	11
Reddy *et al*., 2016	?	+	?	-	-	10
Ahmed *et al*., 2018	?	?	?	-	-	8
Dewake *et al*., 2017	?	?	?	-	-	8

+ Low risk of bias ? Unclear risk of bias - High risk of bias

Figure 2. Quality summary and risk of bias assessment. Note: [1]Cohort study: maximum score of 18, Cross-sectional study: maximum of score of 14. [2]Adapted from Downs and Black (Downs and Black, 1998) ranking scores range from 0 to 18 (higher values indicate higher quality). [3]Adapted from Cochrane Collaboration (Higgins et al., 2011).

Synthesis of results and meta-analyses

Overall, nine of the 11 studies assessing the relationship between greater SOC and dental clinical measurements provided data for six meta-analyses (Figure 3).

There was no association between SOC and number of teeth when data from five studies involving 7297 participants were pooled [OR = 1.02; 95%CI = 0.95-1.08] (Bernabé *et al*., 2010; Davoglio *et al*., 2016; Lindmark *et al*., 2010; Possebon *et al*., 2017; Wennström *et al*., 2013). There was high heterogeneity between studies.

The odds of dental caries was 16% lower among adults and elderly people with higher SOC than those with lower SOC when combining data from six studies involving 7443 participants [OR = 0.84; 95%CI = 0.73-0.96] (Ahmed *et al*., 2018; Bernabé *et al*., 2010; Da Silva e Vettore, 2016; Davoglio *et al*., 2016; Lindmark *et al*., 2010; Wennström *et al*., 2013). In sensitivity analysis the study with high risk of bias was excluded from the meta-analysis (Ahmed *et al*., 2018), which resulted in a similar pooled estimate [OR = 0.84; 95%CI = 0.71-0.97), with heterogeneity still being high (I^2 = 64.4%).

The likelihood of having periodontal disease among adults and elderly people with higher SOC was 42% lower than those with lower SOC when data from four studies involving 6829 participants were combined [OR = 0.58; 95%CI = 0.30-0.85] (Ahmed *et al*., 2018; Bernabé *et al*., 2010; Lindmark *et al*., 2010; Reddy *et al*., 2016). Sensitivity analysis excluding studies of high risk of bias (Ahmed *et al*., 2018; Reddy *et al*., 2016) reduced heterogeneity to 0%. The combined estimate did not show major changes (OR = 0.61; 95%CI = 0.33-0.90).

Adults and elderly people with higher SOC had 46% lower probability of gingivitis than those with lower SOC [OR = 0.54; 95%CI = 0.18-0.90]. The pooled estimate was obtained using data from 619 adults and elderly people from two studies (Lindmark *et al*., 2010; Neves *et al*., 2013).

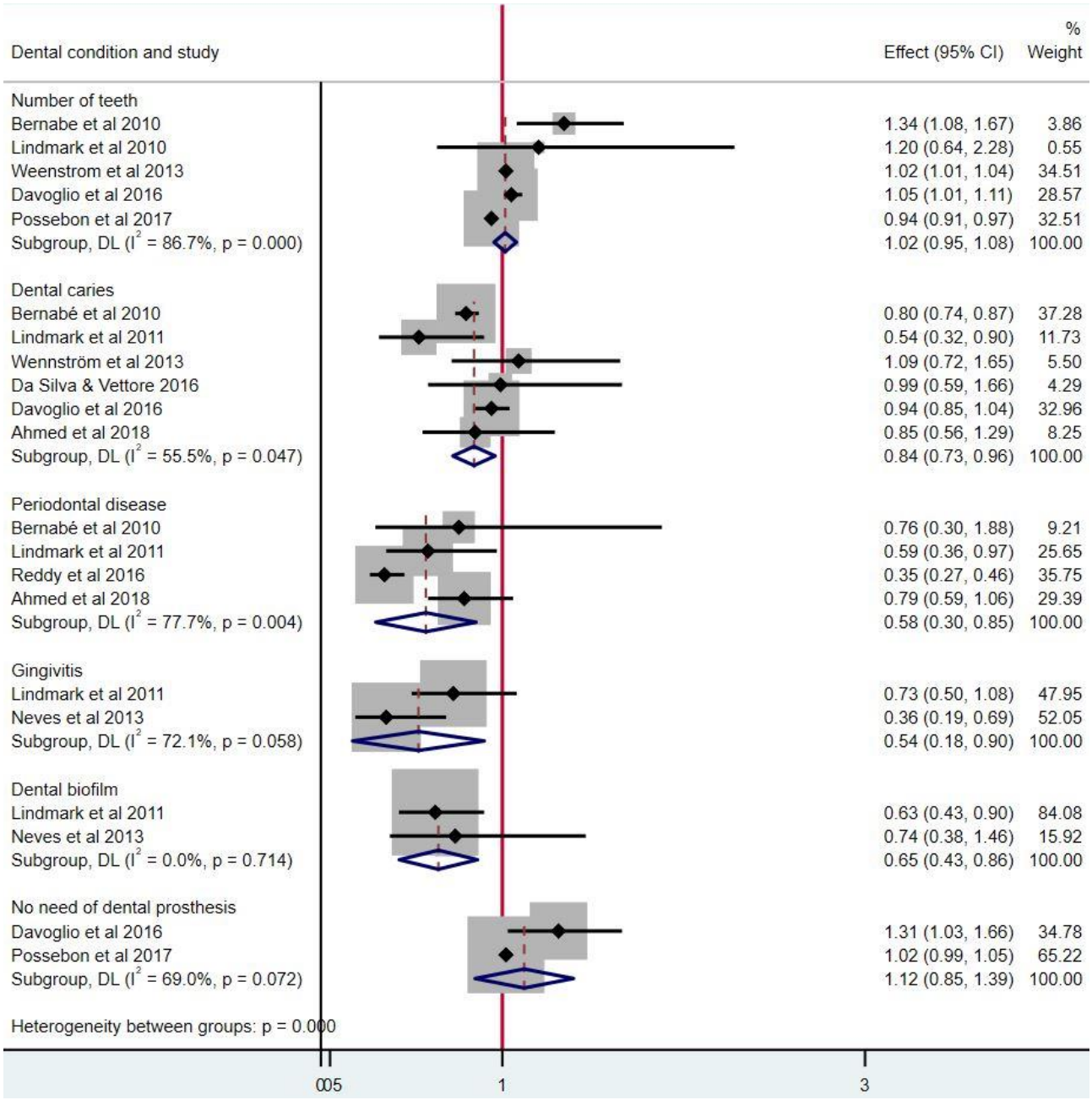

Figure 3. Meta-analysis on the association between greater SOC and oral clinical conditions in adults and elderly people.

Adults and elderly people with higher SOC had lower odds of having dental biolfilm than those with lower SOC [OR = 0.65; 95%CI = 0.43-0.86]. Data from two studies involving 619 adults and elderly people ere used to obtain the pooled estimate (Lindmark *et al*., 2010; Neves *et al*., 2013).

Data from two studies involving 884 participants were pooled to assess the relationship between SOC and dental prosthesis need. SOC was not associated with dental prostheses need [OR = 1.12; 95%CI = 0.85-1.39].

Discussion

The aim of this systematic review was to assess the relationship between SOC and oral clinical conditions in adults and elderly people. The main findings suggest that adults and elderly people with higher SOC were less likely to have dental caries, periodontal disease, gingivitis and dental biofilm than those with lower SOC.

The association between SOC and oral clinical conditions in adults and elderly people can be explained by the possible mediating role of health-related behaviours. For instance, SOC was a strong predictor of frequency of tooth brushing and regular dental care. Moreover, higher SOC was associated with greater access to preventive oral health measures and restorative dental treatment (Bernabé *et al*., 2009). A systematic review showed that SOC is a psychosocial factor associated with oral health-related behaviours. The review suggested that SOC is an important predictor of healthy diet, regular dental visits, and higher frequency of toothbrushing (Elyasi *et al*., 2015). There is consistent evidence that these behaviours are considered protective factors for oral diseases (Lee *et al*., 2019).

According to our findings, higher SOC was associated with lower levels of dental caries. This finding is consistent with a previous review study that demonstrated that lower SOC was a psychosocial factor related to dental caries across different age groups. The possible role of SOC on the occurrence of dental caries highlights the importance of considering SOC in preventive and health promotion approaches (Torres *et al*., 2019). Of the six studies examining the link between SOC and dental caries, only two associated higher SOC and lower dental caries. It is interesting to note that these were the only studies classified of low risk of bias (Bernabé *et al*., 2010/Bernabé *et al*., 2012/Kanhai *et al*., 2014; Lindmark *et al*., 2011). This observation, associated with the heterogeneity found in the meta-analysis, reinforces the need to conduct further well-designed studies to confirm the present findings.

Periodontal diseases, assessed as clinical attachment loss or gingivitis, were related to SOC. The pooled estimate on the association between SOC and periodontal disease obtained in the sensitivity analysis did not show meaningful changes when studies of low methodological quality were removed, which supports the robustness of the findings. The two studies with high risk of bias, also presented important methodological discrepancies, such as the inclusion of participants predominantly of one sex and from specific settings (Ahmed *et al*., 2018; Reddy *et al*., 2016). One study including younger female adults associated higher levels of SOC with less periodontal disease (Reddy *et al*., 2016). Less periodontal disease in patients with higher SOC was observed in a sample of 120 adult Indian male bus drivers (Ahmed *et al*., 2018). Analytical adjustment to attenuate the role of confounding factors on the association between SOC and periodontal disease was not conducted in either study.

The lower occurrence of dental biofilm in patients with higher SOC reinforces the importance of SOC as a psychosocial factor related to oral health behaviours. Since dental biofilm results from inadequate oral cleanliness, oral health promotion strategies should emphasize prevention. Individuals should be able to understand and take up the responsibility for their health, once they are equipped to do so and have autonomy (Arrica *et al*., 2017; Fry and Zask, 2017).

Systematic reviews involving meta-analysis using data extracted from observational studies are prone to heterogeneity. Therefore, our findings on the possible link between SOC and the number of teeth and periodontal disease should be viewed with caution, given the high heterogeneity in the meta-analyses. The small number of studies included in those meta-analyses did not allow the identification of the source of heterogeneity through meta-regression. However, the methodological variability between studies is noteworthy. For example, the age range of participants varied between studies. Moreover, the number of teeth and periodontal disease are strongly related to age.

Studies evaluating the relationship between SOC and self-reported oral health measures were out of scope of the present review. Despite their importance, the use of subjective outcomes in health research has limitations. Moreover, this theme was already examined in a previous systematic review (Gomes *et al*., 2018). Another point that deserves discussion refers to considering three articles as a single study (Bernabé *et al*., 2010, 2012; Kanhai *et al*., 2014). Despite employing different research designs and evaluating distinct clinical outcomes, they derive from the same epidemiological study. This choice is in accordance with the systematic reviews methodology where the number of studies should be considered instead of the number of publications (Li *et al*., 2020).

Some studies included in this review evaluated SOC and oral health among individuals aged 60 years and over (Cyrino *et al*., 2016; Davoglio *et al*., 2016; Dewake *et al*., 2017; Lindmark *et al*., 2016; Possebon *et al*., 2017). SOC reaches stability at around 30 years-old and might decrease when the individual retires (Antonovsky, 1987). However, SOC increased with age in a large sample of male and female Swedish adults and elderly people, aged from 18 to 85 years (Nilsson *et al*., 2010).

The comprehensive search and the absence of restrictions on the search period and language can be considered the strengths of this review. However, the following limitations should be acknowldeged. First, our findings should be interpreted with caution since most studies were cross-sectional. The different biases related to cross-sectional studies may have influenced their results. Second, some included studies did not account for important confounding variables, such as demographic and socioeconomic characteristics (Ahmed *et al*., 2018; Dewake *et al*., 2017; Reddy *et al*., 2016). Third, SOC was predominantly assessed using SOC-13. However, SOC scores were analyzed as continuous variable in some studies but categorized the participants into different levels using different thresholds.

Fourth, some studies included participants with particular characteristics, such as only females (Da Silva and Vettore, 2016; Wennström *et al*., 2013), only males (Ahmed *et al*., 2018), those of young age (Reddy *et al*., 2016) and elderly people (Dewake *et al*., 2017). The specific features of sample from some studies may have impacted in our findings. Finally, two studies were not included in the meta-analysis because the estimates could not be extracted (Cyrino *et al*., 2016; Dewake *et al*., 2017).

Finally, there is a need for longitudinal and intervention studies to examine further the possible influence of SOC on oral clinical conditions in adults and elderly people using reliable and standardized measures. Additional evidence may support planning individual and collective oral health promotion strategies within the frame of of the salutogenic model.

Conclusion

Greater SOC may positively influence oral clinical conditions in adults and elderly people. The evidence is mostly of moderate quality from cross-sectional studies. The salutogenic model acknowledges that SOC is a generalized disposition that is not susceptible to modifications in adult age. Future longitudinal and intervention studies are needed to confirm the present findings.

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Appendix 1. Search strategy according to each database used.

PubMed = 481 (2019/01/20)	
(((Oral health[MeSH Terms]) OR Gingivitis[MeSH Terms]) OR Periodontal diseases[MeSH Terms]) OR Periodontitis[MeSH Terms] OR Dental caries[MeSH Terms] OR Periodontal Index[MeSH Terms] OR Dental Plaque Index[MeSH Terms] OR Oral Hygiene Index[MeSH Terms] OR "Oral health"[Title/Abstract] OR Gingivitis[Title/Abstract] OR "Periodontal diseases"[Title/Abstract] OR Periodontitis[Title/Abstract] OR "Dental caries"[Title/Abstract] OR "Periodontal Index"[Title/Abstract] OR "Dental Plaque Index"[Title/Abstract] OR "Oral Hygiene Index"[Title/Abstract] OR "Oral health conditions"[Title/Abstract] OR "periodontal conditions"[Title/Abstract] OR CPI[Title/Abstract] OR PIP[Title/Abstract] OR "Community Periodontal Index"[Title/Abstract] OR "Root caries"[Title/Abstract] OR "periodontal pocket"[Title/Abstract] OR "Number of teeth"[Title/Abstract] OR "Dental status"[Title/Abstract] OR "Tooth loss"[Title/Abstract]	(((Sense of coherence[MeSH Terms]) OR "sense of coherence"[Title/Abstract]) OR "sense of coherence scale"[Title/Abstract]) OR "salutogenic model"[Title/Abstract] OR "salutogenic approach"[Title/Abstract] OR "salutogenic theory"[Title/Abstract] OR "salutogenic concept"[Title/Abstract] OR salutogenesis[Title/Abstract])
#1 AND #2	
Scopus= 77 (2019/01/20)	
((TITLE-ABS-KEY ("oral health") OR TITLE-ABS-KEY (gingivitis) OR TITLE-ABS-KEY ("periodontal diseases") OR TITLE-ABS-KEY (periodontitis) OR TITLE-ABS-KEY ("dental caries") OR TITLE-ABS-KEY ("periodontal index") OR TITLE-ABS-KEY ("dental plaque index") OR TITLE-ABS-KEY ("oral hygiene index") OR TITLE-ABS-KEY ("oral health conditions") OR TITLE-ABS-KEY ("periodontal conditions") OR TITLE-ABS-KEY (cpi) OR TITLE-ABS-KEY (pip) OR TITLE-ABS-KEY ("community periodontal index") OR TITLE-ABS-KEY ("root caries") OR TITLE-ABS-KEY ("periodontal pocket") OR TITLE-ABS-KEY ("number of teeth") OR TITLE-ABS-KEY ("dental status") OR TITLE-ABS-KEY ("t??th loss")))	((TITLE-ABS-KEY ("sense of coherence") OR TITLE-ABS-KEY ("sense of coherence scale") OR TITLE-ABS-KEY ("salutogenic model") OR TITLE-ABS-KEY ("salutogenic approach") OR TITLE-ABS-KEY ("salutogenic theory") OR TITLE-ABS-KEY ("salutogenic concept") OR TITLE-ABS-KEY (salutogenesis)))
#1 AND #2	
Web of Science = 72 (2019/01/20)	
TOPIC: ("oral health") OR TOPIC: (gingivitis) OR TOPIC: ("periodontal diseases") OR TOPIC: (periodontitis) OR TOPIC: ("dental caries") OR TOPIC:("periodontal index") OR TOPIC: ("dental plaque index") OR TOPIC: ("oral hygiene index") OR TOPIC: ("oral health conditions") OR TOPIC: ("periodontal conditions") OR TOPIC: (CPI) OR TOPIC: (PIP) OR TOPIC: ("community periodontal index") OR TOPIC: ("root caries") OR TOPIC: ("periodontal pocket") OR TOPIC: ("number of teeth") OR TOPIC: ("dental status") OR TOPIC: ("teeth loss")	TOPIC: ("sense of coherence") OR TOPIC: ("sense of coherence scale") OR TOPIC: ("salutogenic model") OR TOPIC: ("salutogenic approach") OR TOPIC:("salutogenic theory") OR TOPIC: ("salutogenic concept") OR TOPIC: (salutogenesis)
LILACS and BBO = 11 (2019/01/20)	
tw:((mh:("oral health")) OR (mh:("gingivitis")) OR (mh:("periodontal diseases")) OR (mh:("periodontitis")) OR (mh:("dental caries")) OR (mh:("periodontal index")) OR (mh:("dental plaque index")) OR (mh:("oral hygiene index")) OR (tw:("oral health")) OR (tw:(gingivitis)) OR (tw:("periodontal diseases")) OR (tw:(periodontitis)) OR (tw:("dental caries")) OR (tw:("oral health conditions")) OR (tw:("periodontal conditions")) OR (tw:(CPI)) OR (tw:(PIP)) OR (tw:("dental plaque index")) OR (tw:("community Periodontal Index")) OR (tw:("dental Plaque Index")) OR (tw:("oral Hygiene Index")) OR (tw:("DMTF index")) OR (tw:("periodontal Index")) OR (tw:("root caries")) OR (tw:("periodontal pocket")) OR (tw:("number of teeth")) OR (tw:("dental status")) OR (tw:("tooth loss")) OR (tw:("Índice periodontal")) OR (tw:("cárie dentária")) OR (tw:("caries dental")) OR (tw:("Índice de placa dental")) OR (tw:("índice de placa dentária")) OR (tw:("índice periodontal")) OR (tw:(gengivite)) OR (tw:(periodontite)) OR (tw:("índice de hygiene oral")) OR (tw:("doenças periodontais")) OR (tw:("enfermidades periodontales")) OR (tw:("saúde bucal")) OR (tw:("salud bucal")) OR (tw:("caries radicular")) OR (tw:("bolsa periodontal")) OR (tw:("pérdida de diente")) OR (tw:("perda de dente")) OR (tw:("condiciones orales")) OR (tw:("condição de saúde bucal"))))	(tw:((tw:((mh:("sense of coherence")) OR (tw:("sense of coherence")) OR (tw:("salutogenic theory")) OR (tw:("salutogenic concept")) OR (tw:("sense coherence")) OR (tw:("salutogenic model")) OR (tw:("salutogenic approach")) OR (tw:("sense of coherence scale")) OR (tw:("coherence sense")) OR (tw:("senso de coerência")) OR (tw:("teoria salutogênica")) OR (tw:(salutogênese)) OR (tw:(salutogeneses)) OR (tw:("sentido de coherencia")) OR (tw:("teoria salutogénica")) OR (tw:("modelo salutogénico"))))))

Appendix 1.Continued overleaf...

Appendix 1 continued. Search strategy according to each database used.

#1 AND #2 AND (db:(“LILACS” OR “BBO”))	
Cochrane Library = 1 (2019/01/20)	
#1 MeSH descriptor: [Oral Health] explode all trees #2 MeSH descriptor: [Gingivitis] explode all trees #3 MeSH descriptor: [Periodontal Diseases] explode all trees #4 Any MeSH descriptor in all MeSH products #5 MeSH descriptor: [Dental Caries] explode all trees #6 MeSH descriptor: [Periodontal Index] explode all trees #7 MeSH descriptor: [Dental Plaque] explode all trees #8 MeSH descriptor: [Oral Hygiene Index] explode all trees #9(“oral health”):ti,ab,kw OR (“gingivitis”):ti,ab,kw OR (“periodontal near diseases”):ti,ab,kw OR (“periodontitis”):ti,ab,kw OR (“dental caries”):ti,ab,kw OR #10 (“periodontal index”):ti,ab,kw OR (“dental plaque index”):ti,ab,kw OR (“oral near hygiene”):ti,ab,kw OR (“oral near health”):ti,ab,kw OR (“periodontal conditions”):ti,ab,kw) OR #11 (CPI):ti,ab,kw OR (PIP):ti,ab,kw OR (“community periodontal index”):ti,ab,kw OR (“root caries”):ti,ab,kw OR (“periodontal pocket”):ti,ab,kw OR #12 (“number of teeth”):ti,ab,kw OR (“dental status”):ti,ab,kw OR (“tooth loss”):ti,ab,kw #1 OR#2 OR#3 OR#4 OR#5 OR#6 OR#7 OR#8 OR#9 OR#10 OR#11 OR#12	#14 MeSH descriptor: [Sense of Coherence] explode all trees #15 (“salutogenic concept”):ti,ab,kw OR (“salutogenesis”):ti,ab,kw #14 OR #15 #13 AND #16
#8 AND #16	