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Role of employment in 11-year changes of clinical oral health - A multilevel longitudinal analysis

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Knowledge Transfer Statement

The findings of this study can help clinicians and oral health policy makers to reorient oral health services towards those who are unemployed as a risk group for poor oral health. The research highlights the role of employment in the longitudinal changes of clinically determined oral health taking into consideration other socioeconomic factors. The study concluded that unemployment seemed to have a role in social inequalities of oral health.

Abstract

The objective was to investigate the role of employment in the 11-year changes of clinically determined oral health. We used data from the longitudinal Health 2011 Survey including re-invited subjects from the Health 2000 Survey. Data were gathered by clinical oral examinations, interviews, and questionnaires of those aged 30 - 63 yrs (n=1,031) in 2000. Exposures were change in employment from baseline to follow-up and length of unemployment. Outcomes measures were the numbers of missing teeth, sound teeth, filled teeth, decayed teeth, and teeth with periodontal pockets (≥ 4 mm and ≥ 6 mm). Separate mixed-effects and conventional negative binomial regression models were fitted for each oral health outcome. Demographic, socioeconomic, and oral health-related behaviors were added as covariates to the analyses. The findings showed that unemployment was associated with poorer clinically determined oral health at baseline but inconsistently with changes in oral health. These effects were attributed to income and education and, to a lesser extent, oral health-related behaviors. The length of unemployment was also inconsistently associated with oral health. The study concluded that as one socioeconomic factor, unemployment had partial impact on oral health.

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Introduction

In industrialized countries, unemployment burdens the social welfare and health care system, as numerous implications and consequences of unemployment manifest themselves in society. These individual and communal implications range from financial, social and psychosocial to more specifically health-related. The detrimental effects of unemployment on general health and health-related behaviors such as alcohol use and smoking have been widely researched in medical studies (Al-Sudani et al. 2016; Burgard et al. 2007; Eliason and Storrie 2009; Mulia et al. 2014; Paul et al. 2009; Prochaska et al. 2013).

Oral health, an essential part of general health, is constantly under environmental and behavioral exposures that may lead to accumulated diseases in dental tissues (Gupta et al. 2015; Holst and Schuller 2012). One part of these environmental factors is socioeconomic position (SEP), including unemployment. Previous research has concluded that unemployment is associated with periodontitis (Croucher et al. 1997), the number of missing teeth (MT) (Mundt et al. 2007), and dental caries (Roberts-Thomson and Stewart 2008). Likewise, we found unemployment to be associated with poor oral health (Al-Sudani et al. 2015). Nonetheless, all these studies were based on cross-sectional data, in which the direction of the association cannot be identified.

A longitudinal study showed that less education and low income were associated with progression of periodontitis and tooth loss (Buchwald et al. 2013). A cohort study explored the relationship of environmental (SEP and social network) and individual factors (social support, stress, subjective SEP, oral health beliefs, and dental behaviors) on clinical and subjective oral health (Gupta et al. 2015). The study concluded that SEP might influence oral health through direct or indirect factors (social support, stress, oral health beliefs, and behaviors). Furthermore, a recently published cohort study concluded that poor social position and weak social ties were important predictors for tooth

loss (Vettore et al. 2016). Nonetheless, these studies did not take employment into consideration in their analyses, and suggested including it in future studies.

Theoretically, the association of unemployment with ill health is conceptualized in two competing hypotheses: causation (which asserts that unemployment could lead to ill health directly or indirectly) and selection (which posits that ill health could lead to unemployment directly or indirectly) (Marmot 2006). Even though unemployment and health problems were found to be intertwined in their association, the causation hypothesis seemed to be a plausible explanation (Kroger et al. 2015). Therefore, the hypothetical standpoint of the present study is the causation hypothesis.

The aim of this study was to investigate the role of employment in the 11-year changes of clinically determined oral health (CDOH) and to test the causation hypothesis that unemployment predisposes to poor oral health.

Materials and Methods

Study sample and participants

This study used data from two national surveys in Finland (Fig. 1). The Health 2000 Survey (https://www.thl.fi/fi/tutkimus-ja-asiantuntijatyo/vaestotutkimukset/terveys-2000-2011) was a nationwide survey of the Finnish adults aged ≥ 18 years, using stratified two-stage clustered sampling of 15 largest towns and 65 health districts in Finland (Aromaa 2004). The total sample size was 9,922. Of these, those who were ≥ 30 years old were invited to participate in the health examination. Of them, 7,087 subjects (88%) were interviewed, and 6,335 subjects (79%) participated in the clinical oral health examination. In addition, subjects were requested to fill in self-administered postal questionnaires.

The Health 2011 Survey was a follow-up study of the Health 2000 Survey (Lundqvist and Mäki-Opas 2016). The members of the Health 2000 Survey sample, who were alive, living in Finland, had contact details available, and had not refused to participate were invited to participate in the follow-up survey. Only those adults living in southern or northern parts of Finland (2 of the 5 examination areas n=3,713) were invited to participate in the clinical oral examination, and 1,496 agreed (40%).

The present study included participants with available information about demographics (age, gender), SEP (employment, education, and income), oral health-related behaviors (OHRB) (tooth brushing frequency, dental attendance, smoking, and alcohol consumption) and CDOH. The final sample in this study comprised those who participated in clinical oral examinations, both at baseline and follow-up and were at baseline dentate, less than 64 yrs old and answered the question about their main activity (n=1,031) (Fig. 1). The Ethical Committee for Research in Epidemiology and Public Health at the Hospital District of Helsinki and Uusimaa in Finland approved the baseline and the follow-up study. A written informed consent was obtained from all participants. This study conforms to STROBE guidelines for human observational studies.

Employment status

Information about employment was elicited with a question during the interview at baseline: 'Which of the following alternatives best describes your current main activity?'. The answering options were dichotomized for this study as unemployed (including laid off) and employed (full-time employment, part-time employment, student, retired, management of own household or care of family members, conscript or non-military service, and others). The rationale behind including the abovementioned groups under the category 'employed' was that none of them were 'job seekers' (i.e. available to the labor market) and all received their respective financial support for reasons other than being unemployed (e.g. student or military allowance, retirement, and those who reported

management of own household or care of family members). Information about the length of unemployment was obtained with the question 'How many months has your current unemployment or lay-off period lasted?'. The answers were categorized into ≤1, >1–2, >2–5, and >5 yrs. Unemployment for longer than 1 yr was considered long-term unemployment (OSF 2016). Information about employment and length of unemployment was collected in a similar manner at the follow-up in 2011. In this study, we used three forms of employment status as exposure factors; change of employment status from baseline to follow-up as dichotomized, employment status as categorized into four (stable employed are those who were employed in both surveys, stable unemployed were those who were unemployed in both surveys, the third category was those who were employed at baseline but were unemployed at follow-up, and the fourth category was those who were unemployed at baseline and became employed at follow-up) and finally the length of unemployment at baseline.

Clinically determined oral health

Identical clinical oral examinations were conducted in both surveys, as part of the health examinations. The clinical oral examinations were performed by calibrated dentists with the aid of a dental nurse or an oral hygienist based on the methodology of the Mini-Finland Survey (Vehkalahti 1991) as well as WHO guidelines (WHO 1997). All the examiners received similar training by the same experienced dentists. At the baseline survey, the overall kappa values for inter- and intra-examiner reliability were 0.87 and 0.95 at tooth level for dental findings and 0.36 and 0.66 for periodontal findings respectively (Suominen-Taipale 2004; Suominen 2008). A dental chair, a portable dental unit, a high-powered suction motor, and a headlamp were used. The dental instruments used in the study were; a dental mirror, a fiber optic light, and a World Health Organization (WHO)-approved periodontal probe (Suominen 2008).

The teeth were blown dry before the status of all tooth surfaces was examined, and observations were recorded for each tooth as follows: sound; decayed (either primary or secondary caries cavities

extending into the dentine, separately for coronal or root surfaces or both); filled (no caries lesion); fractured; and residual root, with or without caries. The presence of teeth was recorded by tooth and included all teeth or tooth remnants that were visible and tactile in the mouth. The number of MT was calculated by subtracting the number of teeth present from the maximum number of teeth (28 teeth). Thus, subjects with ≥ 28 teeth were considered having no MT. Except for the wisdom teeth, periodontal pocket depth was measured on four sites of each tooth, and the highest value for each tooth was recorded as follows: 0, no pockets; 1, at least one pocket ≥ 4 mm; 2, at least one pocket ≥ 6 mm.

Demographic, socioeconomic factors

At the baseline, information about age and gender was based on population registers. Information about income had been collected from self-reported monthly household income during the health interview, which was then formatted into OECD (Organization for Economic Co-operation and Development) equivalence scale, which allocates a weight of 1 to the first household member, 0.7 to each additional adult, and 0.5 to each child under 18 yrs old (OECD 1982). The OECD- income was used as equal thirds in the analyses and was categorized into lowest, middle, and highest. The education level of the participants comprised information about their basic education (eight options ranging from 'less than elementary school' to 'matriculation examination') and vocational education (11 options ranging from 'no vocational education' to 'doctoral degree'). The educational level was then classified into three categories: basic, intermediate, and higher (Heistaro 2008).

Oral health-related behaviors

Tooth brushing frequency was assessed with the question: 'How often do you usually brush your teeth?' The answer was marked on a 5-point response scale (more often than twice a day, twice a day, once a day, less often than every day, or never). Dental attendance was inquired during the interview by asking: 'Do you usually go to a dentist?' The response was reported on a 3-point scale 'regularly for check-ups, only when you have toothache or some other trouble, or never?'

(Suominen 2008). Smoking history was determined in the interview and further categorized as follows: daily smoker, occasional smoker, or non-smoker. Information about alcohol use was collected with the questionnaire, which included a question concerning average alcohol consumption during the previous 12 months in bottles per week, which was later converted into grams per week.

Statistical analysis

The Non-parametric test (Kruskal Wallis rank test) was used to calculate the probability values for the difference in CDOH among categories of change of employment, and of length of unemployment (Table 1).

The association between employment status and change of CDOH was analyzed both by multilevel mixed-effects and conventional models employing negative binomial regression due to over-dispersion of the model's fitted values. Mixed-effects models (Table 2 and 4) were used to analyze the change in oral health while conventional negative binomial regression models (Table 3) were used to analyze oral health at follow-up. In the mixed-effects models, the main effects model of employment status estimates the effects on CDOH at baseline. To assess the effect of employment status on change of CDOH over the 11 years, we added an interaction (= product term) between employment status and the time indicator (= year) to the models. Separate models were fitted for each outcome. The number of teeth present was used as an offset variable except for the number of MT. The exposures were change of employment status from baseline to follow-up and length of unemployment at baseline.

Demographic, SEP, and OHRB were used as covariates and sequential adjustments of the possible confounders or mediators were used in all models. The associations in conventional models were also adjusted for baseline oral health. In the mixed-effects models, sex and income at baseline (income information for the follow-up study was not available) were considered as time-invariant

covariates, while age, year of examination, education, dental attendance, tooth brushing frequency, smoking history, and amount of alcohol used (g/week) were considered as time-variant covariates.

This study included clustering levels; level one: strata (15 largest towns and 5 university hospital districts), level two: health center districts, and level three: individual level. Clustering affects the outcome estimates due to the hierarchical structure of the collected data at baseline and follow-up. Multilevel mixed-effects models deal efficiently with clustering effects; hence, they were used to estimate the longitudinal association of employment and the change of CDOH. In the mixed-effects models, three clustering levels were used as random effects whereas exposures, outcomes and covariates were used as fixed effects. Stratum was excluded from survey weights and random effects due to no convergence. Mixed-effects models handle well the correlation of repeated measures of the same individual, missing data, irregularly spaced measures, and time-invariant and time-variant covariates, making full use of all available data from each subject (Detry and Ma 2016; Fleming et al. 2013). One advantage is that missing data in the outcome measure can be ignored if the missing responses can be explained either by covariates in the model or by the responses available from a given subject. Additionally, using mixed-effects models, valid estimates of exposure can often be obtained even when the missing values are not completely random, so that additional methods for handling missing data, such as multiple imputations, are generally not required (Gibbons et al. 2010). Furthermore, we used weighting to account for item and unit non-response in all models. Stata 14.0 (Stata Corporation, College Station, Texas, USA) was used for the statistical analyses.

Results

Compared to the employed, the unemployed at baseline had higher mean numbers of MT, DT, PT ≥ 4 mm and PT ≥ 6 mm at both baseline and follow-up. There were no differences in oral health according to the length of unemployment in either of the surveys (Table 1).

The main effect model showed that being unemployed was positively associated with MT and teeth with PT ≥ 4 mm and negatively associated with FT and ST when adjusted for sex, age and year (Model 1, Table 2). When further adjusted for other SEP indicators (income and education) and oral health-related behaviors, employment status remained associated with FT only, but this association reversed. Unemployed adults had greater FT than those employed.

The effect on employment status on the change in CDOH over 11 years was evaluated by adding the interaction of employment status with year to the main effect model. This model showed that unemployment was negatively associated with the rate of change in MT and FT when adjusted for sex, age, and year. That is, the increment in number of MT and FT was lower (IRR 0.8, 95% CI 0.7-0.9 and IRR 0.9, 95% CI 0.9-1.0, respectively) in unemployed than employed adults. Only the association with the rate of change in MT remained statistically significant when further adjusted for income, education, dental attendance and tooth brushing.

Those who were stable unemployed, i.e., who were unemployed in both surveys, had a higher number of DT and a higher number of PT ≥ 4 mm in 2011 in unadjusted model and when adjusted for age, sex and baseline oral health. However, the associations with the number of DT and PT ≥ 4 mm were weakened when further adjusted for income and education. Those who were unemployed at baseline and became employed at follow-up had a higher number PT ≥ 4 mm in 2011. The association remained statistically significant when adjusted for income and education. However, smoking and the use of alcohol attenuated the association with number of PT ≥ 4 mm (Table 3).

Length of unemployment was inconsistently associated with CDOH measures at baseline. Those who had been unemployed for a longer time (measured in months) had a lower number of MT.

Those who had been unemployed over 5 yrs had a lower number of FT and a higher number of ST and PT ≥ 6 mm than those who were unemployed ≤ 1 yr at baseline. In addition, those who had been unemployed from 1 to 2 yrs had a higher number of ST (Table 4). The length of unemployment was not associated with the rate of change in CDOH measures (i.e. the interaction term with year was not significant when added to the corresponding main effects model).

Discussion

Our findings partially support the causation hypothesis that unemployment predisposes to poor oral health. Unemployment was associated with poor oral health at baseline and, to a lesser extent, inconsistently with changes in oral health. Income and education accounted for the effects especially for condition of teeth. Oral health-related behaviors, which had smaller effect, appeared to serve as possible mediators in the association of unemployment and periodontal health. The length of unemployment at baseline was inconsistently associated with oral health.

These findings were in line with several studies evaluating the association of unemployment with poor oral health (Croucher et al. 1997; Mundt et al. 2007; Roberts-Thomson and Stewart 2008). Likewise, our study concurred with longitudinal studies demonstrating income and education to be mediators for poor oral health (Buchwald et al. 2013; Gupta et al. 2015; Vettore et al. 2016). These studies suggest that unemployment may affect poor oral health via less income or lower level of education. In comparison to former research (Buchwald et al. 2013; Gupta et al. 2015; Vettore et al. 2016), our study provided new information on the association of unemployment with CDOH. Adjustment for income and education attenuated the association with MT and ST at baseline. In addition, the detected lower rate of change in FT among the unemployed turned out to be insignificant after adjustments for income and education. Such information could be used to understand better the SEP inequalities in oral health. Length of unemployment >5 yrs was not associated with ST at baseline when unadjusted for sex, age, year, income and education.

Nonetheless, the association became significant after adjusting for dental attendance and tooth brushing, which suggests that self-care such as tooth brushing or visiting a dentist regularly could play a role in maintaining the number of ST also among the long-term unemployed.

Work is part of the social structure in Finnish society. In Finland as well as the rest of Europe, unemployment is a SEP burden with consequences on wellbeing and everyday life routines. The Social Insurance Institution (SII) is a Finnish governmental body responsible for the social welfare of the unemployed. The financial benefits for the unemployed are unemployment allowance (basic or earnings-related) and labor market subsidy. The allowance is paid for 500 days (5 days/ week). Those who do not meet the conditions for allowances might be eligible for labor market subsidy. This subsidy is payable to the job seekers who enter the labor market for the first time or who otherwise lack recent work experience, and to the long-term unemployed. According to Statistics Finland's labor Force Survey, the annual average of the unemployment rate was 9.1% and 7.8% in 2001 and 2011 respectively, the years when the two waves of the Health Survey were conducted (OSF 2012).

Participants' response rate in the oral examination at follow-up was rather low due to several factors, but most importantly, due to the long interval between the two wave points of the study. The lowest non-response rates were observed among the youngest men. Those who did not participate in the survey could be persons who had not visited a dentist. The use of weights in the analyses corrected for non-response. These weights were based on age, sex, living area and mother language in 2000 and on age, sex, education, physical activity, use of alcohol, use of vegetables, size of household and body mass index in 2011 (Lundqvist and Mäki-Opas 2016). We could not include income as a time-variant covariate in the analyses because these data were not available. This could affect the outcome estimates because realistically, the participants' income would change over time. We did not assess the progression of periodontal pockets in those who were healthy at baseline and developed periodontal pockets at the follow-up, or the change of PT $\geq$ 4 mm

to ≥ 6 mm at follow-up. The effect of missing data should not be ignored in panel settings; nevertheless, mixed-effects models handled well the missing data by using all available data of the exposures, covariates and outcomes.

The present study sheds light on the longitudinal association between unemployment and clinical oral health. We also used several outcomes of CDOH, including the number of MT, FT, ST, DT, and PT ≥ 4 mm, and ≥ 6 mm. We used several classifications of employment including change in employment and length of unemployment. Methodological and statistical studies recommend using mixed-effects models in the analyses of complex data such as oral health data (Detry and Ma 2016; Gibbons et al. 2010), because such robust models provide estimates that are more precise and take into consideration problems in longitudinal data, such as missing data and correlation among clusters. Finally, we used conventional negative binomial regression model (Table 3) to analyze the association of change of employment with oral health at the follow-up.

In this study, we did not test the selection theory (poor oral health may lead to unemployment) or the relationship between unemployment and subjective oral health. Future research in these aspects could give a better understanding such relationship. Further investigation into the association of employment with progression of oral diseases such as periodontal pockets would provide different insight into this issue. Previous studies have suggested that unemployment is a psychosocially stressful experience, which could influence oral health (Akhter et al. 2005; Aleksejuniene et al. 2002; Peruzzo et al. 2007). It has been suggested that two physiological pathways (via the autonomic nervous system, or the sympathetic nervous system) for the stress to affect physiological functions in the human body including oral health (Boyapati and Wang 2007).

Our study concluded that unemployment was inconsistently associated with changes in clinically determined poor oral health. Socioeconomic position mainly played a role in this relationship and, to a lesser extent, oral health-related behaviors, which implicates the complex network of social

determinants of oral health. These findings also provided new information of unemployment in respect to social inequalities in oral health, which could be useful in preventing oral health inequalities.

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Table 1 Clinically determined oral health (cross-sectional mean numbers of missing teeth=MT, filled teeth=FT, sound teeth=ST, decayed teeth=DT, teeth with periodontal pockets=PT) in 2000 and 2011 according to employment status at baseline

Employment status	MT (n=2053)		FT (n=2046)		ST (n=2043)		DT (n=2046)		PT ≥ 4 mm (n=2008)		PT ≥ 6 mm (n=2008)	
	2000	2011	2000	2011	2000	2011	2000	2011	2000	2011	2000	2011
	Mean (SE)											
Unemployed in 2000 (n=66)	4.7 (0.9)	7.7 (0.2)	13.3 (0.7)	11.8 (0.8)	9.6 (0.8)	10.6 (1.0)	0.5 (0.2)	1.2 (0.5)	5.0 (0.9)	6.8 (1.2)	1.0 (0.3)	1.2 (0.5)
Employed in 2000 (n=965)	3.4 (0.2)	7.8 (1.0)	14.0 (0.2)	14.0 (0.2)	10.4 (0.2)	9.7 (0.2)	0.4 (0.04)	0.4 (0.04)	4.0 (0.2)	4.4 (0.2)	0.5 (0.06)	0.5 (0.4)
P value†	0.133	0.613	0.245	0.018	0.191	0.549	0.721	0.048	0.744	0.095	0.154	0.046
Length of unemployment												
≤1 yr (n= 76)	3.9 (1.0)	7.6 (1.2)	14.5 (0.9)	11.6 (0.9)	9.1 (0.9)	11.5 (1.3)	0.4 (0.2)	0.7 (0.3)	4.3 (0.9)	6.3 (1.3)	0.6 (0.3)	1.5 (0.7)
>1–2 yr (n=17)	5.3 (3.0)	8.8 (2.6)	10.6 (2.1)	12.0 (1.2)	12.7 (3.4)	10.6 (2.0)	0.1 (0.1)	0.4 (0.3)	2.7 (0.9)	9.1 (3.5)	0.2 (0.1)	0.3 (0.3)
>2–5 yr (n=17)	7.1 (2.4)	5.4 (1.4)	11.5 (1.9)	15.0 (3.6)	9.0 (2.4)	6.6 (1.6)	0.5 (0.3)	3.4 (3.4)	7.1 (2.8)	6.4 (4.9)	2.3 (1.2)	0.4 (0.2)
>5 yr (n=5)	5.2 (4.3)	19.0 (-)	11.7 (4.0)	1.0 (-)	10.5 (1.5)	0 (-)	0.7 (0.7)	12 (-)	8.2 (6.6)	10 (-)	2.5 (2.5)	2 (-)
P value†	0.537	0.313	0.143	0.146	0.775	0.231	0.788	0.235	0.911	0.762	0.444	0.359

† Kruskal-Wallis rank test, p-values for the difference between unemployed and employed for each year of examination SE= Standard error of mean

Table 2. Mixed-effects negative binomial regression models for the association between unemployment and clinically determined oral health (number of missing teeth=MT, filled teeth=FT, sound teeth=ST, decayed teeth=DT, teeth with periodontal pockets=PT) over 11 yrs; IRR (Incidence Rate Ratio), 95% CI, P-value.

Oral health	**Main effects**		**Main effects with interaction**					
	Model 1	Model 2	Model 1			Model 2		
	Unemployed	Unemployed	Unemployed	Unemployed #Year	Year	Unemployed	Unemployed #Year†	Year
MT (n=2053)	1.3 (1.1-1.6)	0.9 (0.8-1.1)	1.5 (1.2-1.9)	0.8 (0.7-0.9)	1.7 (1.4-1.9)	1.1 (0.8-1.3)	0.8 (0.7-1.0)‡	1.8 (1.6-2.1)
P-value	0.001	0.545	0.000	0.020	0.000	0.532	0.035	0.000
FT (n=2046)	0.9 (0.9-0.9)	1.1 (1.0-1.1)	1.0 (0.9-1.0)	0.9 (0.9-1.0)	0.8 (0.8-0.9)	1.1 (1.0-1.1)	0.9 (0.9-1.0)	0.8 (0.8-0.9)
P-value	0.020	0.020	0.914	0.049	0.000	0.013	0.098	0.000
ST (n=2043)	0.9 (0.8-0.9)	1.0 (0.9-1.1)	0.9 (0.8-0.9)	1.0 (0.9-1.1)	1.2 (1.2-1.3)	0.9 (0.8-1.0)	1.0 (1.0-1.1)	1.2 (1.2-1.3)
P-value	0.000	0.758	0.001	0.674	0.000	0.133	0.217	0.000
DT (n=2046)	1.5 (0.7-3.3)	0.6 (0.3-1.1)	1.2 (0.5-3.0)	1.7 (0.9-3.1)	0.7 (0.5-1.0)	0.6 (0.2-1.3)	1.4 (0.6-3.4)	0.8 (0.6-1.2)
P-value	0.284	0.115	0.678	0.087	0.095	0.179	0.451	0.327
PT ≥ 4 mm (n=2008)	1.5 (1.1-1.9)	1.1 (0.9-1.4)	1.3 (0.8-2.0)	1.3 (0.8-2.2)	0.8 (0.6-1.2)	1.0 (0.7-1.4)	1.5 (0.9-2.3)	0.9 (0.6-1.3)
P-value	0.005	0.318	0.229	0.268	0.376	0.952	0.076	0.504
PT ≥ 6 mm (n=2008)	1.9 (0.6-6.0)	1.0 (0.4-2.6)	2.1 (0.6-7.1)	0.9 (0.5-1.7)	0.4 (0.2-0.6)	1.4 (0.4-4.5)	0.7 (0.4-4.5)	0.4 (0.2-0.6)
P-value	0.247	0.915	0.231	0.739	0.000	0.543	0.373	0.000

Model 1: Adjusted for age, sex, and year

Model 2: Model 1 + adjusted for income, education, dental attendance, tooth brushing, smoking, and alcohol

† Not adjusted for smoking and alcohol due to non-convergence.

‡ Not adjusted for dental attendance and tooth brushing due to non-convergence

Table 3 Negative binomial regression for the association of employment status with clinically determined oral health at follow-up in 2011 (numbers of missing teeth=MT, filled teeth=FT, sound teeth=ST, decayed teeth=DT, teeth with periodontal pockets=PT); IRR=Incidence Rate Ration, 95% CI= 95% Confidence Interval

Oral health in 2011		Unadjusted	Adjusted		
			Model 1	Model 2	Model 3
				IRR (95% CI)	
MT	Stable employed			Reference	
	Stable unemployed	1.0 (0.7-1.4)	1.1 (0.8-1.5)	0.9 (0.6-1.3)	1.0 (0.8-1.4)
	Employed in 2000-unemployed in 2011	1.0 (0.9-1.2)	1.1 (0.9-1.3)	1.1 (0.9-1.2)	1.1 (0.9-1.3)
	Unemployed in 2000-employed in 2011	1.0 (0.9-1.2)	1.1 (1.0-1.2)	1.0 (0.9-1.1)	1.1 (0.9-1.3)
FT	Stable employed			Reference	
	Stable unemployed	0.9 (0.7-1.1)	0.9 (0.8-1.1)	1.0 (0.8-1.2)	1.1 (0.9-1.4)
	Employed in 2000-unemployed in 2011	0.9 (0.9-1.0)	0.9 (0.8-1.0)	0.9 (0.9-1.0)	1.0 (0.8-1.1)
	Unemployed in 2000-employed in 2011	1.0 (0.9-1.0)	1.0 (0.8-1.1)	1.0 (0.9-1.1)	1.0 (0.9-1.1)
ST	Stable employed			Reference	
	Stable unemployed	0.9 (0.8-1.1)	0.9 (0.8-1.1)	1.0 (0.8-1.2)	1.1 (0.9-1.2)
	Employed in 2000-unemployed in 2011	1.0 (0.9-1.1)	1.0 (0.9-1.1)	1.0 (0.9-1.1)	0.9 (0.8-1.1)
	Unemployed in 2000-employed in 2011	1.0 (0.9-1.1)	1.0 (0.9-1.1)	1.0 (0.9-1.2)	1.0 (0.9-1.2)
DT	Stable employed			Reference	
	Stable unemployed	4.0 (1.4-11.5)	4.5 (1.4-14.4)	1.9 (0.4-10.0)	0.8 (0.2-2.7)
	Employed in 2000-unemployed in 2011	1.8 (0.9-3.7)	2.2 (1.0-4.8)	2.3 (0.9-5.5)	2.1 (0.9-5.0)
	Unemployed in 2000-employed in 2011	1.2 (0.7-2.0)	1.2 (0.7-2.1)	0.7 (0.3-1.5)	0.8 (0.3-2.2)
PT ≥ 4 mm	Stable employed			Reference	
	Stable unemployed	1.8 (1.1-3.0)	2.0 (1.1-3.6)	1.7 (0.9-3.2)	1.4 (0.5-3.8)
	Employed in 2000-unemployed in 2011	1.2 (0.7-1.8)	1.1 (0.7-1.8)	1.1 (0.7-1.8)	0.9 (0.5-1.5)
	Unemployed in 2000-employed in 2011	1.4 (1.0-1.8)	1.4 (1.1-1.9)	1.4 (1.0-1.9)	1.3 (0.9-2.0)
PT ≥ 6 mm	Stable employed			Reference	
	Stable unemployed	1.7 (0.6-4.7)	1.9 (0.7-5.0)	1.0 (0.3-2.9)	1.7 (0.6-4.9)
	Employed in 2000-unemployed in 2011	1.4 (0.5-3.7)	1.7 (0.6-5.1)	2.2 (0.6-8.5)	0.7 (0.2-1.7)
	Unemployed in 2000-employed in 2011	0.9 (0.5-1.8)	0.9 (0.5-1.6)	0.7 (0.4-1.5)	1.4 (0.5-3.7)

Offset variable: number of teeth for all outcomes, except MT

Model 1: Age, sex, and baseline oral health ， Model 2: Model 1+ income and education

Model 3: Model 2+ tooth brushing, dental attendance, smoking and alcohol

Table 4 Mixed-effects negative binomial regression models of the association of length of unemployment at baseline with clinically determined oral health (numbers of missing teeth=MT, filled teeth=FT, sound teeth=ST, decayed teeth=DT, teeth with periodontal pockets=PT)

Oral health	Length of unemployment	Unadjusted	Adjusted	
			Model 1	Model 2
				IRR (95%CI)
MT	≤ 1 yr (Reference)			
	> 1-2 yr	1.3 (0.7-2.1)	0.9 (0.5-1.8)	0.6 (0.3-1.1)
	>2-5 yr	1.0 (0.7-1.4)	0.9 (0.6-1.5)	0.5 (0.4-0.7)
	>5 yr	1.2 (0.6-2.2)	0.7 (0.1-5.9)	1.1 (0.4-8.8)
	As continuous†	1.00 (1.00-1.00)	1.00 (0.99-1.01)	0.97 (0.95-0.98)
FT	≤ 1 yr (Reference)			
	> 1-2 yr	0.9 (0.7-1.2)	0.8 (0.7-1.0)	0.8 (0.7-1.0)
	>2-5 yr	1.0 (0.8-1.3)	0.9 (0.7-1.2)	1.0 (0.8-1.4)
	>5 yr	0.7 (0.6-1.0)	0.7 (0.5-1.1)	0.7 (0.5-0.9)
	As continuous†	0.99 (0.99-0.99)	0.99 (0.99-1.00)	0.99 (0.99-1.00)
ST	≤ 1 yr (Reference)			
	> 1-2 yr	1.1 (0.9-1.3)	1.2 (1.0-1.4)	1.4 (1.1-1.7)
	>2-5 yr	0.9 (0.7-1.2)	0.9 (0.7-1.3)	0.8 (0.5-1.4)
	>5 yr	1.0 (0.7-1.5)	1.5 (0.8-2.5)	1.5 (1.0-2.1)
	As continuous†	0.99 (0.99-1.00)	1.00 (0.99-1.00)	1.00 (0.99-1.00)
DT	≤ 1 yr(Reference)			
	> 1-2 yr	0.6 (0.1-2.6)	0.3 (0.06-1.8)	0.3 (0.05-1.5)
	>2-5 yr	1.1 (0.1-8.4)	0.9 (0.2-5.0)	0.2 (0.02-1.2)
	>5 yr	2.2 (0.7-7.3)	6.0 (0.5-6.8)	5.1 (0.3-8.9)
	As continuous†	1.00 (1.00-1.01)	1.00 (0.98-1.02)	0.99 (0.96-1.02)
PT ≥ 4 mm	≤ 1 yr(Reference)			
	> 1-2 yr	1.2 (0.6-2.6)	1.2 (0.7-1.9)	1.2 (0.6-2.4)
	>2-5 yr	1.1 (0.3-4.0)	0.7 (0.3-1.6)	0.5 (0.2-1.6)
	>5 yr	1.1 (0.3-3.8)	1.1 (0.6-2.1)	1.1 (0.5-2.3)
	As continuous†	1.00 (0.98-1.01)	0.99 (0.98-1.01)	0.99 (0.97-1.01)
PT ≥ 6 mm	≤ 1 yr (Reference)			
	> 1-2 yr	0.4 (0.06-3.8)	0.3 (0.03-3.15)	0.3 (0.04-2.3)
	>2-5 yr	2.4 (0.5-11.5)	0.9 (0.2-3.6)	0.3 (0.1-1.1)
	>5 yr	1.3 (0.6-2.9)	2.5 (0.5-11.1)	5.9 (1.8-19.1)
	As continuous†	1.00 (0.98-1.02)	1.00 (0.98-1.02)	1.00 (0.99-1.01)

†Unemployment in months, IRR= Incidence Rate Ratio, 95% CI= 95% Confidence Interval.
Model 1: Age, sex, year, income and education
Model 2: Model 1+ tooth brushing, dental attendance, smoking and alcohol
Offset variable: number of teeth for all outcomes, except for MT

Figure 1 Flow Chart for the inclusion criteria of the final study sample