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Chronic diseases and Edentulism over a 7-year-period in China: Findings from the China Health and Retirement Longitudinal Study

Qiuping ZHOU
University of Hong Kong
Walter Yu Hang LAM
University of Hong Kong
Colman McGrath
mcgrathc@hku.hk

University of Hong Kong

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Abstract

Background

There is a scarcity of longitudinal, population-level evidence on the association between chronic diseases and tooth loss. This study aimed to determine the association between chronic diseases and edentulism over a 7-year period.

Methods

Data were obtained from the *China Health and Retirement Longitudinal Study* (CHARLS), 2011 and 2018 waves. Experiences of 14 chronic diseases (doctor diagnosed) were recorded at baseline and follow-up. Association between chronic disease experience and edentulism was determined in regression analyses accounting for demographic factors (age, gender, educational attainment, marital status, neighbourhood) and behaviour (smoking and drinking). Furthermore, association between developing chronic disease and becoming edentulous over the 7-year period was examined adjusting for demographic and behavioural factors.

Results

Number of chronic diseases was associated with a higher odds of being edentulous and remained so after adjusting for demographic status and behavioural factors in 2011 ($N = 16300$) OR 1.06, 95%CI 1.02–1.10, $P < 0.01$ and in 2018 ($N = 19431$) OR 1.03, 95%CI 1.01–1.05, $P < 0.05$. Longitudinal analyses of dentate participants without chronic disease at baseline ($N = 3956$) identified that those who developed a chronic disease over the 7-year period had a higher odds of becoming edentulous, accounting for demographic and behavioural factors: OR 1.29, 95%CI 1.04–1.59, $P < 0.05$. Sub-analyses identified that those who developed specific diseases had higher odds of becoming edentulous: heart disease (OR 1.20, 95% CI 1.03–1.40, $P < 0.05$), asthma (OR 1.27, 95%CI 1.01–1.61, $P < 0.05$) and arthritis (OR 1.18, 95%CI 1.01–1.37, $P < 0.05$).

Conclusions

Chronic disease status is associated with edentulism. The development of chronic disease over a 7-year period is associated with increased odds of becoming edentulous and development of specific disease poses increased odds of becoming edentulism.

1.0 Introduction

Edentulism, the loss of all teeth is a consequence of a lifetime experience of chronic oral diseases, namely as results of dental caries and periodontal diseases [1]. It has long been suggested that edentulism is part of the general health problems faced by older adults given their increasing incidences and coexistence in older age [2]. To this end there have been calls to examine the evidence of general health status's association with oral health, and particularly how chronic disease influences tooth loss so as to understanding their potential link, shared pathways and causalities [3]. This has implication in raising awareness of the role of oral health as a component of chronic health and for advocating integrated care.

The link between chronic disease and poor oral health is complex for which several plausible theories of their coexistence have been proposed [4]. The co-occurrence of chronic disease and poor oral health can be explained by their shared common risk factors such as smoking, poor nutrition and the underling social determinants across the life course [5, 6]. The inflammatory theory relates to how chronic oral infections lead to elevated systemic inflammatory responses contributing to development and progress of chronic disease as well as tooth loss and thus their co-occurrence [7, 8]. The link between chronic disease and poor oral health have also been explained by way of the immune response theory whereby infections stimulate and exacerbate autoimmune responses resulting in increased risk of tooth loss and progression of chronic diseases [9]. Imbalances in oral microbiota by way of the microbial dysbiosis theory may also explain the link to the development of chronic disease and influence disease progression [10, 11]. Moreover, there are several examples of a bi-directional relationship between oral disease and systemic disease where poorly controlled contributed chronic disease worsening oral health, and vice-versa [12, 13].

Numerous clinical patient-based studies have identified poor oral health among those with chronic diseases, and in particular the risk of tooth loss. For example, severity of lower urinary tract infection was shown to be associated number of remaining teeth, and it remained an independent risk factor associated with overactive bladders adjusting for age and comorbidities [14]. Furthermore population-based studies have identified that participant with chronic disease experience more severe forms of tooth loss and more liked to be edentulous. For example, an increased risk of several chronic disease associated with edentulism in a Brazilian National Health Survey [15]. The National Health and Nutrition Examination Survey in the United States identified that the prevalence of chronic kidney disease was associated with edentulism [16]. In addition, those experiencing multiple long-term chronic diseases (multimorbidity) are reported to have an increased odds of experiencing severe tooth loss and more than twice the likelihood to be edentulous [17].

Evidence of the longitudinal association between chronic disease and tooth loss is less readily available particularly among large population samples that would have the necessary sample power to identify their association controlling for key socio-demographic and behavioural factors [4]. This study aimed to identify the association between experience of chronic disease and edentulism among middle and older age adults in China. To examine over a 7-year period the association between development of chronic diseases and becoming edentulous. In addition, to explore the association between development of 14 chronic disease and the likelihood of becoming edentulous in middle and older age adults.

2.0 Methods

2.1 Study Population

The data for this study was derived from the *China Health and Retirement Longitudinal Study* (CHARLS), a large cohort study of a nationally representative sample of middle age and older Chinese residents. A sample of more than 17,000 Chinese residents aged 45 and older were recruited through a multistage probability sampling method across 28 provinces, 150 counties and 450 villages in 2011 [18]. Data collection began in 2011, with subsequent waves every two years. In this study analyses were conducted on cohort participants over a 7-year period [2011–2018] that collected data on oral health and chronic diseases.

2.2 Data Collection

Oral Health Status: The dental condition of this study was edentulous status as determined by response to the question ‘Have you lost all of your teeth’, with response options of ‘yes’ or ‘no’ in 2011 and 2018. Among those who were dentate in 2011 (responded to not having lost all their teeth) their response to the oral health question in 2018 was used to classify participants as having ‘become edentulous’ or ‘remained dentate’.

Chronic Diseases: To assess chronic disease status, the respondents were asked: ‘Have you been diagnosed with [14 conditions listed below, read one by one] by a doctor? (yes or no)’. These chronic disease included (1) hypertension; (2) dyslipidaemia including elevation of low-density lipoprotein, triglycerides (TGs) and total cholesterol, or a low high-density lipoprotein level; (3) diabetes or high blood sugar; (4) cancer, excluding minor skin cancers; (5) chronic lung diseases, such as chronic bronchitis and emphysema, excluding cancer; (6) liver disease, except fatty liver and cancer; (7) heart disease including heart attack, coronary heart disease, angina, congestive heart failure or other heart problems; (8) stroke; (9) kidney disease, excluding cancer; (10) stomach or other digestive diseases, except for tumour or cancer; (11) emotional, nervous or psychiatric problems; (12) memory related disease, such as dementia, or Parkinson's disease; (13)

arthritis or rheumatism; and (14) asthma. A proxy interview was used if the respondent could not complete the survey, for example, when the respondent was physically or cognitively impaired, in a hospital, or could not be tracked by the field teams during the fieldwork period. In most cases, a close family member, such as a spouse or child, assumed this role. The number of chronic diseases was calculated as a measure of multimorbidity- a continuous variable. Among those who were free of any chronic disease in 2011 and subsequently developed a chronic disease over the 7-year period they were classified as ‘developed chronic disease’ (yes or no), a binary categorical variable.

Covariates: Information on a range of demographic characteristics were collected based on common factors associated with health status and trajectories of chronic disease in China [19]. Age, gender, educational attainment, marital status and residency neighbourhood were employed as covariates. Age was a continuous variable. Gender was a binary categorical variable - male or female. Educational attainment was based on highest level of schooling reported to be obtained - ordinal categorical variable: graduation from secondary school or above’, ‘graduation from primary school’ or ‘no formal education’. Marital status was derived based on response to ‘living with a spouse’ or ‘living without a spouse’- binary categorical variable. Type of residential neighbourhood was based on their survey community ID, which indicated whether the respondents lived in a rural or urban area. Information on two key behaviours, smoking and drinking, were obtained given their importance as predictor of chronic diseases [20]. Smoking status was classified as ‘never smoked’ versus ‘ever smoked’, while alcohol consumption was categorized as ‘never drank’ versus ‘ever drank’.

2.3 Statistical Analyses

Prior to analysing the relationship between edentulous status and chronic disease differences in categorical and continuous variables between the non-edentulous and edentulous groups were assessed. Categorical variables are presented as counts (percentages), and between-group differences were compared using Pearson's chi-square test. Continuous variables were expressed as means ± standard deviations and differences were analysed by t-test.

The association between edentulous status and number of chronic diseases was assessed in cross sectional analyses of the 2011 and 2018 data in binary logistic regression analyses. Regression models were fitted in two stages: first as crude (unadjusted) models and then adjusted for all demographic and behaviour covariates in a backward Wald regression model.

Longitudinal analyses were then conducted among those who were dentate and had no disease in 2011, the proportion of those who developed chronic disease and proportion who became edentulous over the 7-year period (2011–2018) were ascertained. Regression

models were fitted in two stages with the dependent variable being ‘became edentulous’ and crude (unadjusted) models of association between development of chronic disease and becoming edentulous and then adjusted for all demographic and behaviour covariates in a backward Wald regression model.

Following on, subgroup analyses were performed to determine the association between the development of each of the fourteen specific, doctor-diagnosed chronic diseases over the 7-year period and becoming edentulous in a series of logistic regression models accounting for baseline demographics, behaviours and number of chronic diseases.

3.0 Results

A total of 16,300 individuals were included in the data analyses of 2011, 19,431 individuals in the data analyses of 2018, and 3956 in the longitudinal analyses Fig. 1. The prevalence of edentulism in 2011 was 8.8% (1,435) and 16.4% (3188) in 2018. The characteristics of the cohort in 2011 and 2018 are presented in Table 1. At both time points edentulous participants were older, more frequently females, had no formal education, did not live with a spouse and resided in rural neighbourhoods (all, $P < 0.001$). In terms of behaviour, drinking history was significantly associated with edentulous status ($P < 0.001$) but smoking history was not found to be significantly associated with edentulous status ($P > 0.05$).

Table 1
Profile of Study Population

2011 wave				
Characteristics	Total	Non-edentulous	Edentulous	P-value
Participants, N (%)	16300 (100)	14865 (91.2)	1435 (8.8)	
Age, mean ± SD	59.6 ± 9.8	58.6 ± 9.3	69.8 ± 9.6	< 0.001
Gender, N (%)				< 0.001
male	7974 (48.9)	7344 (49.4)	630 (43.9)	
female	8326 (51.1)	7521 (50.6)	805 (56.1)	
Educational attainment, N (%)				< 0.001
secondary and above	5486 (33.7)	5282 (35.5)	204 (14.2)	
primary	3492 (21.4)	3211 (21.6)	281 (19.6)	
no formal education	7322 (44.9)	6372 (42.9)	950 (66.2)	
Marital status, N (%)				< 0.001
with a spouse	13093 (80.3)	12128 (81.6)	965 (67.2)	
without a spouse	3207 (19.7)	2737 (18.4)	470 (32.8)	
Residency neighbourhood, N (%)				< 0.001
urban	6580 (40.4)	6101 (41.0)	479 (33.4)	
rural	9720 (59.6)	8764 (59.0)	956 (66.6)	
Smoking, N (%)				0.286
never	9745 (59.8)	8906 (59.9)	839 (58.5)	
ever	6555 (40.2)	5959 (40.1)	596 (41.5)	
Drinking, N (%)				< 0.001
never	9841 (60.4)	8894 (59.8)	947 (66.0)	
ever	6459 (39.6)	5971 (40.2)	488 (34.0)	

2011 wave				
Number of diseases, mean ± SD	1.4 ± 1.4	1.3 ± 1.4	1.6 ± 1.5	< 0.001
2018 wave				
Characteristics	Total	Non-edentulous	Edentulous	P-value
Participants, N (%)	19431 (100)	16243 (83.6)	3188 (16.4)	
Age, mean ± SD	62.2 ± 10.2	60.6 ± 9.4	70.7 ± 9.9	< 0.001
Gender, N (%)				< 0.001
male	9266 (47.7)	7883 (48.5)	1383 (43.4)	
female	10165 (52.3)	8360 (51.5)	1805 (56.6)	
Educational attainment, N (%)				< 0.001
secondary and above	6689 (34.4)	6117 (37.7)	572 (17.9)	
primary	4269 (22.0)	3614 (22.2)	655 (20.5)	
no formal education	8473 (43.6)	6512 (40.1)	1961 (61.5)	
Marital status, N (%)				< 0.001
with a spouse	15231 (78.4)	13072 (80.5)	2159 (67.7)	
without a spouse	4200 (21.6)	3171 (19.5)	1029 (32.3)	
Residency neighbourhood, N (%)				< 0.001
urban	5461 (28.1)	4829 (29.7)	632 (19.8)	
rural	13970 (71.9)	11414 (70.3)	2556 (80.2)	
Smoking, N (%)				0.743
never	11170 (57.5)	9329 (57.4)	1841 (57.7)	

2011 wave				
ever	8261 (42.5)	6914 (42.6)	1347 (42.3)	
Drinking, N (%)				< 0.001
never	10827 (55.7)	8904 (54.8)	1923 (60.3)	
ever	8604 (44.3)	7339 (45.2)	1265 (39.7)	
Number of diseases, mean ± SD	2.2 ± 1.9	2.1 ± 1.9	2.6 ± 2.0	< 0.001

At both time periods the number of chronic diseases was significantly associated with edentulous status, Table 2. In 2011, the unadjusted regression model observed that for every increase in the number of chronic diseases the odds of being edentulous increases by 14% (OR 1.14, 95%CI 1.10–1.18, $P < 0.001$). Adjusting for demographic and behavioural factors, for every increase in the number of chronic diseases the odds of being edentulous increases by 6% (OR 1.06, 95%CI 1.02–1.10, $P < 0.01$). In 2018, the unadjusted regression model observed that for every increase in the number of chronic diseases the odds of being edentulous increases by 13% (OR 1.13, 95%CI 1.11–1.15, $P < 0.001$). Adjusting for demographic and behavioural factors, for every increase in the number of chronic diseases the odds of being edentulous increases by 3% (OR 1.03%, 95%CI 1.01–1.05, $P < 0.05$).

Table 2
Number of Chronic Diseases and Edentulism in 2011 and 2018

2021 wave					
Variables		B	S.E.	OR (95% CI)	p-value
Crude model					
Chronic disease (N)		0.13	0.02	1.14 (1.10–1.18)	< 0.001
Adjusted model					
Chronic disease (N)		0.05	0.02	1.06 (1.02–1.10)	0.006
Age (years)		0.10	0.00	1.11 (1.10–1.12)	< 0.001
Gender	male*				
	female	0.31	0.09	1.36 (1.15–1.60)	< 0.001
Education	secondary*				< 0.001
	primary	0.33	0.10	1.44 (1.181–1.75)	< 0.001
	no formal	0.43	0.09	1.53 (1.28–1.83)	< 0.001
Marital status	with spouse*				
	without spouse				> 0.05
Residency	urban*				
	rural	0.32	0.07	1.38 (1.21–1.56)	< 0.001
Smoking	never*				
	ever	0.35	0.08	1.42 (1.21–1.65)	< 0.001
Drinking	never*				
	ever	-0.20	0.07	0.82 (0.71–0.95)	0.006
2018 wave					
Variables		B	S.E.	OR (95% CI)	p-value
Crude model					
Chronic disease (N)		0.12	0.01	1.13 (1.11–1.15)	< 0.001
Adjusted model					
Chronic disease (N)		0.03	0.01	1.03 (1.01–1.05)	0.017
Age (years)		0.10	0.00	1.10 (1.10–1.11)	< 0.000
*Reference group					

2021 wave					
Gender	male*				
	female	0.22	0.07	1.25 (1.09–1.42)	< 0.001
Education	secondary*				< 0.001
	primary	0.28	0.07	1.37 (1.16–1.50)	< 0.001
	no formal	0.42	0.06	1.52 (1.35–1.71)	< 0.001
Marital status	with spouse*				
	without spouse	0.10	0.05	1.10 (1.00-1.22)	0.048
Residency	urban*				
	rural	0.42	0.05	1.53 (1.37–1.70)	< 0.001
Smoking	never*				
	ever	0.17	0.06	1.18 (1.04–1.34)	0.008
Drinking	never*				
	ever	-0.13	0.05	0.88 (0.80–0.97)	0.010
*Reference group					

Longitudinal analyses identified that among the cohort who were dentate and had no disease in 2011, 61.9% (2450/3956) developed a chronic disease over the 7-year period and 13.2% (521/3956) become edentulous. Regression analyses identified that the unadjusted odds for becoming edentulous increased among those who developed a chronic disease compared to those who did not develop a chronic disease; OR 1.48, 95%CI 1.22–1.81 $P < 0.001$, Table 3. Having adjusted for demographic and behavioural factors, developing a chronic disease was associated with a 29% increase in the likelihood of becoming edentulous: OR 1.29,95%CI 1.04–1.59, $P < 0.05$.

Table 3
Association between Developing Chronic Diseases and Becoming Edentulous from 2011 to 2018

Variables		B	S.E.	OR (95% CI)	p-value
Crude model					
Disease status	remain no disease*				
	developing disease	0.40	0.10	1.48 (1.22–1.81)	< 0.001
Adjusted model					
Disease status	remain no disease*				
	developing disease	0.25	0.11	1.29 (1.04–1.59)	0.018
Age (years)		0.09	0.01	1.10 (1.08–1.11)	< 0.001
Gender	male*				
	female	0.23	0.10	1.26 (1.03–1.53)	0.022
Education	secondary*				
	primary				> 0.05
	no formal				
Marital status	with spouse*				
	without spouse				> 0.05
Residency	urban*				
	rural	0.40	0.11	1.43 (1.20–1.83)	< 0.001
Smoking	never*				
	ever				> 0.05
Drinking	never*				
	ever				> 0.05
*Reference group					

Sub analyses identified that there was a significant increase in the odds of becoming edentulous among those who developed specific chronic diseases over the 7-year period. Among those who developed heart disease there was a 20% increase in the likelihood of becoming edentulous, OR 1.20, 95%CI 1.03–1.40, $P < 0.05$. Among those who developed asthma there was a 27% increase in the likelihood of becoming edentulous, OR 1.27, 95%CI 1.01–1.61, $P < 0.05$. Among those who developed arthritis there was a 18% increase in the likelihood of becoming edentulous, OR 1.18, 95%CI 1.01–1.37, $P < 0.05$. No

significant association between becoming edentulous and development of other diseases over the 7-year time period were apparent: including hypertension, dyslipidemia, diabetes, cancer, lung disease, liver disease, stroke, kidney disease, digestive diseases, emotional problems, or memory-related diseases (all p-value > 0.05), *Fig. 2*.

4.0 Discussion

Cross sectional analyses identified that number of chronic diseases was associated with a higher odd of being edentulous in the large random samples of Chinese middle and older age adults; the 2011 and 2018 waves of CHARLS. The number of chronic diseases was associated with somewhat higher odds of edentulism in 2011 than in 2018. This may be attributed to difference in the number of chronic diseases as those in 2018 had a greater mean number of chronic diseases and/or the higher prevalence of edentulism in 2018. Several cross-sectional population studies have identified significant associations between number of chronic diseases and edentulism. Findings for the 2018 American Behavioural Risk Factor Surveillance Survey identified that chronic disease levels was significantly associated with levels of tooth loss and the greatest odds of chronic diseases was among those who were edentulous (OR 1.62) adjusting for socioeconomic and behavioural factors [21]. Findings from the 2019 Brazilian Health Survey (65,803 adults aged 19–59) also identified that chronic diseases was associated with a lower odds of having a functional dentition (0.77) and a higher odds (1.17) of sever tooth loss [22].

Longitudinal analyses of CHARLS dentate participants without chronic disease over the 7-year period identified that those who developed one or more chronic disease had an increased likelihood to become edentulous; almost a 30% increase. Findings from longitudinal analyses are less readily available to make comparisons but there is emerging evidence the developing chronic disease or increase in number of diseases is associated with increased rates of tooth loss. Findings from the American Health and Retirement study identified 10% higher odds of becoming edentulous over a 6-year period (2012–2018) association with chronic disease [23]. Likewise, findings from the American National Health and Nutrition Examination Survey 1999–2004 and 2011–2016 identified that those with chronic disease were more likely to develop severe tooth loss [24].

Sub analyses identified that development of certain chronic diseases was association with becoming edentulous over the 7-year period. Development of asthma was associated with more than a quarter the odds of becoming edentulous, development of heart disease was associated with a twenty percent increase in the odds of becoming edentulous, and developing arthritis was associated with nearly a twenty percent increase in the odds of becoming edentulous. Poor oral health has been attributed to asthmatic factors themselves and the medication used to manage asthma such as corticosteroids leading to xerostomia that increases risk of oral diseases and ultimately greater tooth loss [25]. The

National Health and Nutrition Examination Survey (NHANES) 2019 − 2014 also identified that asthmatic adults had over a third higher odds of experiencing severe tooth loss [26]. Findings from the NHANES 2015–2018 reported that those with cardiovascular conditions (myocardial infarction, coronary heart disease, congestive heart failure and stroke) had a higher prevalence ratio of being edentulous [27]. Heart disease has widely been reported to be associated with periodontal diseases and tooth loss related to shared risk factors, inflammation and bacteraemia. Several cross-sectional studies have identified poor oral health among patients with rheumatoid arthritis, including higher prevalences of tooth loss [28, 29]. Findings from the third National Health and Nutrition Examination Survey in the USA identified that participants with arthritis were more than twice as likely to be edentulous compared participants without arthritis [30]. Moreover, presence and levels of rheumatoid factors and other arthritis-inflammatory markers has been shown to be associated with severity of tooth loss and periodontal disease in cross sectional studies [31]. The German Course and Prognosis of Early Arthritis Study cohort study identified that increased rheumatoid arthritis in terms of number of joints affected and several biomarkers (such as erythrocyte sedimentation rates) were associated with levels of tooth loss, and highest among those with complete tooth loss over a two-year period [32].

The benefit of this study is the large population data base and one of the largest longitudinal studies of the development of chronic disease and development of tooth loss that enabled this exploration of cross-sectional and longitudinal association of chronic diseases and edentulism. The data being from China provide insight from a low-middle income perspective which to date is limited in the literature. A limitation of the study is the lack of available information on rehabilitation of edentulism such as use for dentures, albeit this may be more important to consider if exploring the link between tooth loss and chronic disease as the outcome as opposed to chronic diseases association with outcome of tooth loss.

5.0 Conclusion

In conclusion, two cross-sectional analyses identified that number of chronic diseases was associated with higher odds of edentulism among middle and older Chinese adults. Longitudinal analyses observed that developing chronic disease was associated with an increase in the likelihood of becoming edentulous over a 7-year-period. Development of specific diseases such as heart disease, asthma and arthritis were associated with an increased risk of becoming edentulous over the 7-year period. These findings have implications in raising awareness of the link between chronic diseases and oral health, recognises edentulism as part of the general health problems faced by older adults and calls for the need to further explore how oral care can be integrated in managing chronic diseases.

Declarations

Human Ethics Statement & Consent

CHARLS is a publicly available data set: https://charls.charlsdata.com/pages/Data/harmonized_charls/en.html. Ethical approval for all the CHARLS waves of data collection was granted from the Institutional Review Board at Peking University (IRB00001052-11015) and adheres to the Deceleration of Helsinki regarding medical research involving human subjects. During the fieldwork participations provided their informed consent by signing two copies of the informed consent, and one copy was kept in the CHARLS office and one copy for participant.

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Figures

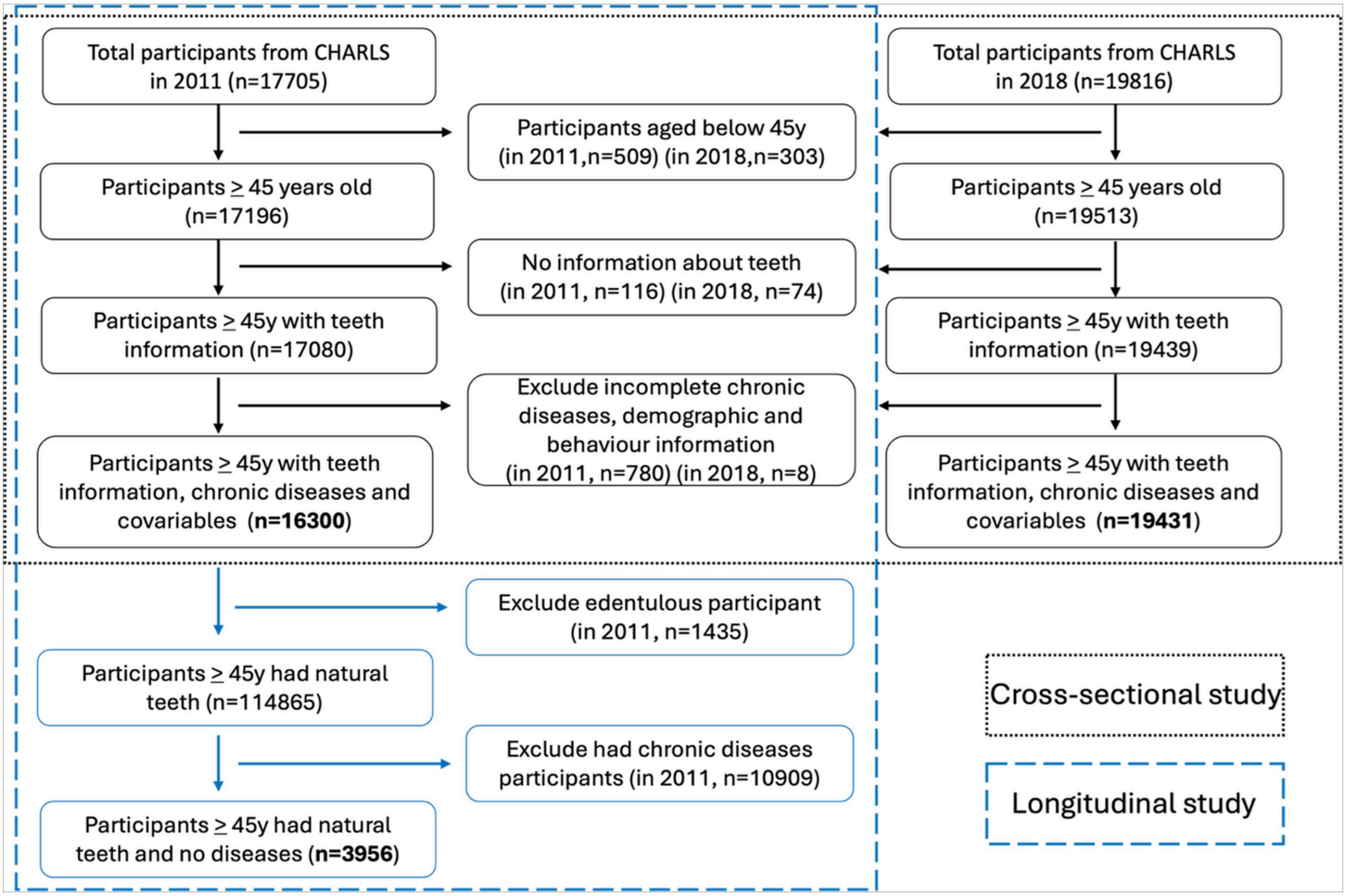


Figure 1

Flowchart

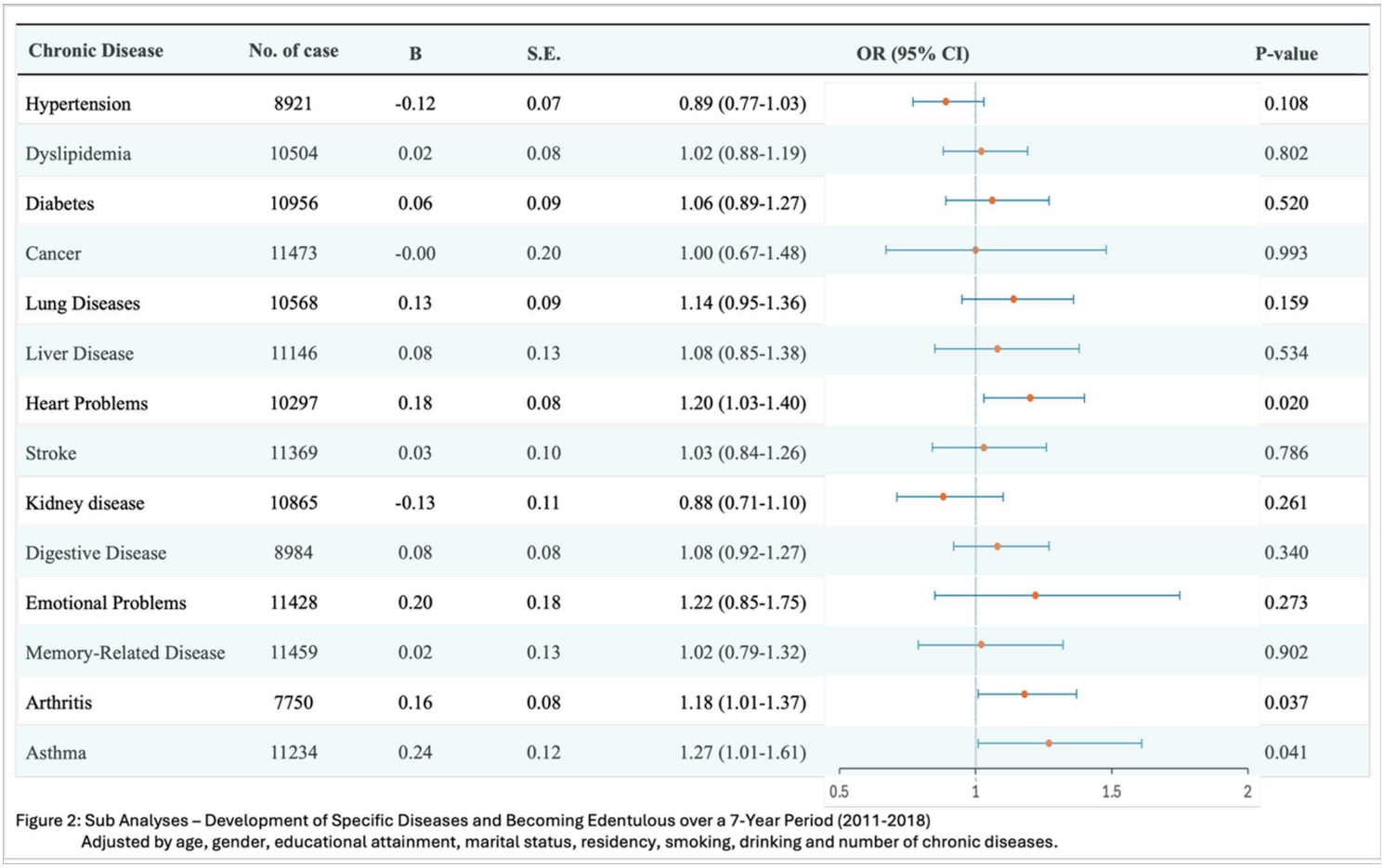


Figure 2: Sub Analyses – Development of Specific Diseases and Becoming Edentulous over a 7-Year Period (2011-2018)
Adjusted by age, gender, educational attainment, marital status, residency, smoking, drinking and number of chronic diseases.

Figure 2

See image above for figure legend