Exploring socio-economic gradients in oral health among a national sample of Thai adults

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Thesis submitted for the degree of Doctor of Philosophy

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-2019-

Declaration

I, Nichamon Chaianant, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Abstract

Background: Evidence on socio-economic inequalities and gradients in oral health status exist around the world. Adults who belong to higher socio-economic groups and live in more privileged neighbourhoods experience better oral health compared to their counterparts. A limited number of studies have explored the socio-economic gradients in oral health status among Thai adults and none have assessed the relationship between area-level socio-economic position and oral health.

Aims: To assess the socio-economic gradients in oral health outcomes, including dental caries experience, periodontal disease and tooth loss among a nationally representative sample of Thai adults aged 35-44 and 60-74 years.

Methods: Secondary analysis of data from the 7th Thai National Oral Health Survey was performed. Single level regression models were used to assess individual-level socio-economic gradients, defined by education and income, in six oral health outcomes, namely DMFT, decayed teeth, filled teeth, deep periodontal pockets, non-functional dentition and edentulousness (total tooth loss). Multilevel regression models were used to determine the socio-economic gradients, accounting for the variation between provinces and adjusted for both individual- and provincial-level covariates.

Results: Regarding individual-level socio-economic position, there were unexpected reverse education and income gradients in DMFT and filled teeth, while there were expected social gradients in decayed teeth, periodontal disease, and tooth loss for both age groups. Regarding provincial-level socio-economic position, provincial poverty was positively associated with only the periodontal disease outcome. In addition, the dentist per population ratio was positively associated with DMFT, filled teeth and periodontal disease. Living in an urban area was more likely to have high DMFT, filled teeth and edentulousness.

Conclusion: The study added evidence on socio-economic gradients in oral health among Thai adults. However, the gradients varied by different socio-economic measures and oral health outcomes. The results also showed that area-level characteristics were independently associated with oral health outcomes.

Impact statement

Oral health inequalities are a major global public health problem. This thesis has added new evidence on oral health inequalities and socio-economic gradients in oral health among a nationally representative sample of Thai adults.

The study showed unexpected reverse socio-economic gradients in filled teeth. Thai adults who had high socio-economic position had more filled teeth and more frequent dental visits during the past year than adults in lower socio-economic groups. This result has important implications for dental practitioners as it suggests that overtreatment maybe occurring in Thailand. Treatment decisions and the recall interval period should be based on evidence-based guidelines in order to minimise excessive treatment. Oral disease prevention and oral health promotion should also be encouraged in the clinical settings.

In addition, adults living in more affluent areas, including Bangkok and the Central area of Thailand, also had a high number of filled teeth. The thesis results also showed that the dentist per 100,000 population was positively associated with the number of filled teeth – the higher number of dentists resulted in more fillings. The uneven distribution of dental personnel in Thailand should be monitored and policies to improve the distribution of personnel should be introduced.

The results also showed that both individual- and area-level factors were associated with oral health inequalities. The Thai Government should closely monitor inequalities and their related causes. Oral health inequalities will not improve by only increasing access to the dental services via introducing universal health coverage scheme or increasing the number of dental professions. More fundamental elements in society such as levels of general education are also very important as the gateway to future opportunities for better quality of life, including better oral health. The multilevel analyses also highlighted variations in oral health status between provinces across Thailand, which indicated that each province has their own particular oral health challenges. Therefore, the government should also provide greater autonomy to the local authorities in order to manage their own budgets, facilities, and human resources to tackle oral health inequalities at the provincial level.

Furthermore, the national Thai oral health survey is a very important and useful source of information on oral health inequalities in Thailand. The national data provides opportunities for researchers to explore further patterns and influences on oral health inequalities. Future collaborations between the Bureau of Dental Health, Ministry of Health and academic researchers on the next Thai national oral health survey will help to ensure that the data collected is relevant and helpful to inform future policies on oral health in Thailand.

Acknowledgments

First and foremost, I would like to express my gratitude to my supervisors, Professor Richard Watt, Dr Georgios Tsakos, and Dr Anja Heilmann. Without their patience, motivation and invaluable supports this research project would not be completed. In particular, I would like to thank: Prof Richard Watt for his academic advice, his words of encouragement helped me overcome many obstacles during the project; Dr Georgios Tsakos for his valuable feedbacks and advice on statistical issues; Dr Anja Heilmann for her moral supports and technical supper with the statistics and English language in my report.

I am highly indebted to the Royal Thai Government and Thammasat University for the financial support during my graduate studies. I also would like to thank all staffs of the Office of Educational Affairs, the Royal Thai Embassy (OEA UK) for their supports during my study in the UK.

I am much obliged to Dr Yuvaboon Chanchamcharoon, the former Dean, Dr Piya Siriphant, and Asst. Prof Dr Weerachai Singhatanadgit who gave me the opportunity to study in UK and I also would like to thank Dr Matana Kettratad and my senior colleagues at Faculty of Dentistry, Thammasat University, for their help and encouragement which helped me throughout my PhD.

I would also like to acknowledge Dr. Piyada Prasertsom, Director of Bureau of Dental Health and all officers from the Bureau of Dental Health for their supports on the dataset and lots of information using in this thesis.

I also gratefully acknowledge my new friends in UK who have made my time in UK a very valuable experience. I would like to thank all friends in Dental Public Health group for their helps and advice on my project and PhD life. Special thanks go to Fifi and her family for their emotional and physical supports during my study in London. My thanks also go to Dr Supathep Tansirichaiya and all Thai dentists in UK for their good friendships and moral supports which helped me get through difficult times.

Last but not least, I am grateful to my beloved family for taking care of themselves and also their understanding, encouragement, emotional supports throughout these years that I have been away from home.

Table of Contents

List of Tables

List of Figures

List of abbreviations

BMI	Body Mass Index
CI	Confidence Interval
CPI	Community Periodontal Index
DMFT	The number of decayed, missing and filled teeth
DT	The number of decayed teeth
FT	The number of filled teeth
GBP	Great British Pound
GDP	Gross Domestic Product
HAI	Human Achievement Index
HDI	Human Development Index
IRR	Incidence Rate Ratio
OR	Odds Ratio
SD	Standard deviation
SE	Standard error
SEP	Socio-economic position
SMR	Standardized Mortality Ratio
SRH	Self-rated health
THB	Thai BAHT
VPC	Variance Partition Coefficient
WHO	World Health Organizations
ZINB	Zero-Inflated Negative Binomial model

Chapter 1 Introduction

Globally, population health and oral health are improving. However, the rates of improving health are different between the poorest and those who are better-off. Therefore, health and oral health inequalities persist (Boutayeb and Helmert, 2011; Crocombe et al., 2010; Do, 2012; Graham and Kelly, 2004). Health inequalities and social gradients are found in most countries and for most chronic diseases, with better health and oral health being concentrated among the better-off (Adler and Ostrove, 1999; Manser and Bauerfeind, 2014; Wilkinson and Pickett, 2008).

Thailand encountered rapid economic growth over the last half-century, and this situation led to economic disparity between regions (Jansen, 2001). In 2012, the proportion of people living in poverty, measured by the Poverty Head Count ratio, was 1.91% in the Bangkok region, but 19.79% in the north-eastern region (Statistical Forecasting Bureau, 2016). The economic disparity between regions may lead to differences in health outcomes (Yiengprugsawan et al., 2009). The Thai Government is concerned about the health differences between regions and between urban and rural areas. As a result, in 2001, the Universal Coverage Scheme was introduced to increase access to health services for the whole Thai population (Pramualratana and Wibulpolprasert, 2002; Yiengprugsawan et al., 2009). The Universal Coverage Scheme has successfully increased healthcare utilisation especially among the poor population (Jongudomsuk et al., 2015). However, health and oral health differences by socio-economic position and geographic factors have still been reported (Yiengprugsawan et al., 2013; Yiengprugsawan et al., 2007).

While health differences between different socio-economic groups have been reported in Thailand, the direction of the reported associations was not always consistent. Most studies reported that poorer health and oral health outcomes were concentrated among individuals with low socio-economic position and/or those living in deprived areas. For example, analyses using nationally representative data showed that lower education and income were associated with poorer self-reported health and a number of chronic diseases (Yiengprugsawan et al., 2009; Zimmer and Amornsirisomboon, 2001), overweight and obesity among women (Aekplakorn et al., 2014) and tooth loss (Srisilapanan et al., 2016). Living in rural areas and areas with low socio-economic position was associated with chronic illness (Yiengprugsawan et al., 2007), poorer self-reported health (Tangcharoensathien et al., 2006), and higher number of decayed teeth (Dental Health Division, 2013b). On the other hand, some studies reported poorer health and oral health status among individuals with higher socio-economic position and/or those living in privileged areas. For example, a large cross-sectional study found that adults who had a higher level of education and income were more likely to be obese (Aekplakorn et al., 2014; Jitnarin et al., 2010), to have higher cholesterol levels and diabetes (Pipatvanichgul et al., 2015), and hypertension (Thawornchaisit et al., 2013b). In addition, living in an urban area or area with high socio-economic position was associated with higher CVD mortality (Petcharoen et al., 2006) and tooth loss (Yiengprugsawan et al., 2011a).

Given these inconsistent findings regarding the existence of social gradients in health and oral health in Thailand, further evidence is required. Previous research among Thai adults has rarely used clinical oral health measures from nationally representative data. Therefore, this study aimed to explore the extent and nature of socio-economic inequalities in oral health among a nationally representative sample of Thai adults. Furthermore, this study was the first Thai study that investigated the

social determinants of oral health status at both individual and area level using multilevel analysis.

Chapter 2 Background and literature review

2.1 Introduction

Inequalities in health and oral health are universal within and between countries (Commission on Social Determinants of Health, 2008; Sgan-Cohen et al., 2013; Sheiham et al., 2011; World Health Organization, 2008). There is evidence that health and oral health are associated with both individual-level and contextual-level socio-economic factors (Ito et al., 2015; Locker, 2000; Meijer et al., 2012; Pickett and Pearl, 2001; Yen et al., 2009). Addressing inequalities in health and oral health are global public health priorities (Marmot, 2015; Watt et al., 2016). In 2016, the United Nations Development Programme (UNDP) developed the Sustainable Developmental Goals (SDGs) to tackle the major global challenges facing the world (United Nations, 2015). An important element of the SDGs (two out of seventeen goals) is the need to improve health and well-being and to reduce inequality. The SDG agenda encourages all countries and all stakeholders to work collaboratively to follow the overall plan as all the goals are interconnected. In addition, the SDGs facilitate the integration of health and also oral health into the broader public policy and development agenda (United Nation, 2015).

In Thailand, health and oral health inequalities also persist, however, the evidence concerning socio-economic gradients and inequalities is still limited and more mixed, especially in relation to oral health (Aekplakorn et al., 2014; Petcharoen et al., 2006; Srisilapanan et al., 2016). Moreover, no Thai study assessed the relationships between area-level socio-economic position and oral health.

The review of the literature will start with a brief overview of the definitions of social inequalities in health, social gradients in health, and socio-economic position, and the possible explanations for health inequalities. This is followed by an overview of key publications on health inequalities and the social gradient in both general and oral health. Then, previous studies on inequalities in oral health among the Thai population will be reviewed, and gaps in the literature will be highlighted.

2.2 Background

2.2.1 Definitions

2.2.1.1 Inequalities in health

According to the Black Report, "the distribution of health or ill-health among and between populations has for many years been expressed most forcefully in terms of ideas on 'inequality'. These ideas are not just 'differences'. There may be differences between species, races, the sexes and people of different age, but the focus of interest is not so much natural physiological constitution or process as outcomes which have been socially or economically determined" (Townsend et al., 1992). Whitehead (1992) also suggested that only health differences that are unnecessary, avoidable and unfair should be defined as health inequalities. Later she defined health inequalities as "systematic differences in health between people in different social classes or socio-economic positions within the society" (Whitehead, 2007). Health differences, which are inevitable and unavoidable, such as biological variation, age or sex differences, are therefore not considered to be health inequalities.

2.2.1.2 Social gradient in health and oral health

A salient phenomenon, first described by Marmot et al. (1978) is that inequalities are not observed only between the rich and the poor extreme ends of the socio-economic spectrum but they follow a gradient. Differences in health status and life expectancy exist at each step from the top to the bottom of the socio-economic ladder in a stepwise fashion. This social gradient suggests a dose-response relationship – health status gets worse as one descends in socio-economic position (Fuhrer et al., 2002; Marmot, 2007; Marmot and Shipley, 1996; Wilkinson and Marmot, 2003).

2.2.1.3 Socio-economic position (SEP)

"Socio-economic position refers to the social and economic factors that influence what position individuals or groups hold within the structure of society" (Galobardes et al., 2006b). Various socio-economic position indicators such as education, income and occupation are used in health inequalities studies but there is no best single indicator. The choice of indicator depends on the health outcome of interest and the relevant stage in the life course. In addition, different socio-economic position indicators may affect the slope of the health gradient differently (Galobardes et al., 2006b).

Frequently used SEP indicators at individual level are education, income and occupation. Education is a basic SEP component that confers knowledge and skills needed to access and learn health-promoting information. Moreover, education also acts as a 'gateway' to future opportunities for occupation and income. Income measures cannot directly affect health but these directly measure material resources, which link to health outcomes (Galobardes et al., 2006b). Income indicates how people can afford their food, housing and education (Adler and Newman, 2002). Occupation is related to both education and income (Borrell and Crawford, 2012). Occupation has direct effects on health through various factors including work hazards, stress and social support. In addition, occupation may also be related to health status via social privilege and position, which may improve access to health care or resources. There are various occupation classifications, which are based on different theories (Bartley, 2004; Galobardes et al., 2006a; Gueorguieva et al., 2009).

Socio-economic position indicators at an ecological level (e.g. area or country level) are also used in health inequality studies to represent socio-economic circumstances of an area where people live. They are used to characterise areas from deprived to privileged and often used as proxy measures when individual measures are not

available. Locker (2000) suggested four different ways of using area-based deprivation measures: 1) use instead of individual-level SEP; 2) in addition to individual-level SEP; 3) to substitute conventional measures, such as social class; 4) to represent needs of health services in small areas. These measures may be collected from individuals or small groups in the areas or obtained from administrative databases (Borrell and Crawford, 2012; Galobardes et al., 2006a). Examples are the proportion of unemployed, proportion of poor population (Poverty Headcount Ratio), proportion in blue-collar or manual occupations, proportion with higher education in an area, Gross Domestic Product per capita (GDP), Gross National Income per capita (GNI), Human Development Index (HDI), and Gini index.

In summary, various SEP indicators are available for different types of studies and different health outcomes. As mentioned earlier, different SEP measures may result in different magnitudes of associations between SEP and health outcomes. Choosing a suitable measure should be based on the mechanism through which each SEP indicator affects differences in health outcomes (Galobardes et al., 2006a).

2.2.2 Explanations for links between socio-economic position and health

Many researchers suggested explanations of how SEP links to health and oral health (Bartley, 2004; Sisson, 2007). Bartley (2017) proposed three broad explanations for the relationship between SEP and health outcomes, including behavioural and cultural factors, materialist model, and psycho-social model, and considering all these effects over the life-course.

The behavioural and cultural explanation suggests that differences in health behaviours between different socio-economic groups or cultures can affect inequalities in health outcomes. The materialist model refers to the role of income,

which is related to better access to relevant services and materials such as healthy food and good housing, which in turn are related to better health outcomes. The psychosocial model posits that health inequalities are the result of differences in psychosocial risk factors between different social strata. In that respect, a low social status may lead to stress, which affects health (Bartley, 2004).

Research on the life-course approach suggests that differences in SEP over time can have a considerable effect on later health through different mechanisms such as critical periods and accumulation of risk (Bartley, 2017; Melchior et al., 2007; Poulton et al., 2002).

Place of living is also related to health outcomes. Macintyre et al. (2002) proposed three explanations for geographical inequalities in health: compositional, contextual, and collective. The compositional explanation suggests that people who are living in the same area may share the same characteristics, for example, poor families are living in deprived areas. Secondly, the contextual explanation is about the physical and social environment in the place of living, for example, quality of air and water, and the availability of public services. The collective explanation presents the role of socio-cultural and historical characteristics of a neighbourhood, for example, norms, resident's morale, and how the area is perceived by residents or investors.

2.2.3 Research on health inequalities and social gradient in health

A vast amount of research provides evidence that various health outcomes, such as mortality rate, life expectancy and diseases, are influenced by socio-economic position at both individual and area level.

2.2.3.1 Individual or household level socio-economic position and general health

A seminal study by Marmot and colleagues (1978) analysed data from 17,530 British civil servants and reported a clear inverse association between employment grade and coronary heart disease that followed a stepwise gradient: a lower employment grade was associated with a higher risk of coronary heart disease mortality.

At the present time, there is copious evidence reporting associations between individual-level socio-economic position and health outcomes such as mortality rate, life expectancy, and general health (Hosseinpoor et al., 2012a; Hosseinpoor et al., 2012b; Huisman et al., 2013; Mackenbach et al., 2008).

Regarding the association between socio-economic position and mortality, Huisman et al. (2013) conducted a systematic review of 44 studies from the WHO Europe region, which showed strong evidence of socio-economic inequalities in all-cause mortality among older people. Another study conducted by Mackenbach et al. (2008) also found that there were education-related health inequalities among adults aged 30-74 years from 22 European countries; less well-educated people had a higher risk of death from all causes than highly educated people.

Regarding the associations between socio-economic position and health status, Hosseinpoor et al. (2012b) conducted a study among adults aged 18 years and over

from 57 countries using data from 2002-2004 World Health Survey. The study found household wealth and education gradients in self-rated health (SRH). Hosseinpoor et al. (2012a) assessed socio-economic inequalities in non-communicable diseases among adults aged 18 years and over in 41 low- and middle-income countries. The results showed that household wealth and education were reversely associated with non-communicable diseases, including asthma, angina, depression, arthritis and co-morbidity conditions. The association between socio-economic position and health among low- and middle-income countries might not be as straightforward as in high income countries. Dinsa et al. (2012) conducted a systematic review on the association between socio-economic position and obesity in low- and middle-income countries. Forty-two studies were included in the review, which found that the evidence on health inequalities was mixed. For example, in low-income countries, obesity was associated with having a higher income for both men and women. While in middle-income countries, the associations were more mixed among men and mainly reverse associations were found among women. The authors suggested possible explanations for the protective effect of the poor in low-income countries may be the lack of energy dense 'processed' food among the poor in those countries and the poor tend to work in manual occupations that requires a high level of physical activity. While the rich in low-income countries could afford and demand extra food that leads to obesity.

2.2.3.2 Area level socio-economic position and health

Unjustifiable health differences are also reported between privileged and less privileged areas. Better health outcomes such as high life expectancy and low mortality rates tend to favour areas or countries with high socio-economic position (Boutayeb and Helmert, 2011; Krieger et al., 2008; Rehkopf et al., 2006; Singh and Siahpush, 2006).

Yen et al. (2009) conducted a systematic review of neighbourhood effects on older adults' health. The review included 33 studies. Six types of neighbourhood characteristics were considered, including socio-economic composition, racial composition, demographics, neighbourhood's problems, physical environment, and social environment. Regarding socio-economic composition, poor health was associated with neighbourhood socio-economic disadvantage. Various neighbourhood socio-economic measures were used to assess the association between neighbourhood and health, for example, gross domestic product per capita (GDP), median household income, income inequalities, and mean year of schooling.

Dow and Rehkopf (2010) reported higher GDP per capita was associated with higher life expectancy up to intermediate income level, but the relationship was weaker as GDP per capita increased, up to no association among high income countries. Mondal and Shitan (2014) reported that life expectancy was also positively related with mean years of education and availability of physicians. Recently, Fan et al. (2015) analysed data from 50 US states and reported an association between state-level socio-economic position and self-reported hypertension. The states with lower median household income and more people living under the poverty line were more likely to have a high prevalence of self-reported hypertension.

Previously the association between area-level socio-economic position and health was assessed by ecological studies which mostly used aggregated information. Without adjustment for individual-level data, the interpretation of the area-level effect might however not be correct. Also, it might be difficult to identify whether the association is caused by context or composition effects. Therefore, multilevel models are increasingly used to facilitate simultaneous assessment of individual- and area-level effects on health (Ross and Mirowsky, 2008).

Studies using multilevel models showed that area-level socio-economic position affects health independently of individual socio-economic position. Pickett and Pearl (2001) conducted a review of multilevel studies on area characteristics and health outcomes. Twenty-five studies were included in the review. The results showed that 23 of the 25 studies reported at least one neighbourhood factor independently and significantly associated with a health outcome. Two systematic reviews reported the association between area-level socio-economic position and mortality after adjusting for individual characteristics (Kondo et al., 2009; Meijer et al., 2012).

A recent study by Masood and Reidpath (2017) conducted multilevel analyses using the data from the World Health Survey, which included adults aged 18 years and over from 70 low-, middle-, and high-income countries, in order to explore the association between BMI, national wealth and Individual household wealth. In contrast to other health outcomes, the study reported positive relationships between individual SEP measures, national income and BMI / obesity; wealthier adults who had higher incomes and lived in richer countries had a higher BMI compared to their counterparts.

In summary, socio-economic position at both individual- and contextual- level are independently associated with health outcomes. Regarding most of the health outcomes, individuals with lower education, lower income, and living in more socio-economically deprived areas have worse health status.

2.2.3.3 Evidence on social inequalities in general health in Thailand

During the 1970s, Thailand experienced social and economic development due to the implementation of the Third National Economic and Social Development plan in 1972 (Office of the National Economic and Social Development Council, 1972). This led to the education reform in 1978, which particularly changed the curriculum and increased compulsory education to primary school (grade 6) and increased to junior high school (Grade 9) in 2002. In addition, in terms of economic development there was low growth from 1970 and then a period of rapid growth from 1985 until 1999 (Teokul, 1999). GDP average annual growth rate was 5.2% in 1980 and this increased to 11.2% by 1990 (Jongudomsuk et al., 2015). During this period of social and economic development in Thailand, the overall health of the Thai population improved. Population data shows increasing life expectancy from 55.1 years in 1960 to 75.30 in 2011. Furthermore, Thailand encountered the epidemiological transition that moved from high fertility and mortality levels to low fertility and mortality levels, and since 1999, the major cause of death have shifted to non-communicable diseases. The data shows age-standardized death rates (A-SDRs) per 100,000 by all infectious and parasitic diseases decreased from 59.4 in 1980 to 32.5 in 1995, while A-SDRs per 100,000 for diabetes and circulatory diseases increased from 5.6 and 80.5 respectively in 1980 to 9.2 and 114.2 in 1995 (Jongudomsuk et al., 2015).

Unlike in developed countries, there is a limited number of studies on the association between socio-economic position and health among Thai adults. The following section reviewed the limited studies on the association between socio-economic position and general health in Thai adults.

Individual- or household-level socio-economic position and general health

Education was the marker of individual socio-economic position that was most commonly used in Thai studies. Some studies reported that poor health outcomes were concentrated among individuals with low education. Adults with low educational attainment were more likely to have poorer health outcomes, such as, high mortality rate (Vapattanawong et al., 2008), overweight, obesity among women (Aekplakorn et al., 2007b; Aekplakorn et al., 2014; Aekplakorn and Mo-suwan, 2009; Jitnarin et al., 2010; Seubsman et al., 2010), self-reported poor health (Yiengprugsawan et al., 2007; Zimmer and Amornsirisomboon, 2001), stroke (Hanchaiphiboolkul et al., 2011), diabetes (Pipatvanichgul et al., 2015), hypertension (Thawornchaisit et al., 2013a), and metabolic syndrome (Lohsoonthorn et al., 2007). On the other hand, some studies reported that individuals with high education were more likely to have poorer health outcomes, such as hypercholesterolemia (Pipatvanichgul et al., 2015), poor self-rated health among men (Seubsman et al., 2011), and obesity among men (Aekplakorn et al., 2007b; Aekplakorn et al., 2014; Aekplakorn and Mo-suwan, 2009; Seubsman et al., 2010).

Income is another socio-economic measure that was frequently used in Thai studies. Similar to education, the association between income and health status was inconsistent. Some studies reported that low income was associated with poorer health outcomes, such as standardized mortality ratio (Vapattanawong et al., 2008), chronic kidney disease (Thawornchaisit et al., 2015), obesity, diabetes, and hypertension among women (Pipatvanichgul et al., 2015; Seubsman et al., 2010), and self-reported poor health status (Tangcharoensathien et al., 2006; Yiengprugsawan et al., 2007; Yiengprugsawan et al., 2009; Zimmer and Amornsirisomboon, 2001). On the other hand, some studies found that higher income levels were associated with overweight and obesity (Jitnarin et al., 2010), hypertension (Thawornchaisit et al.,

2013a), hypercholesterolemia (Pipatvanichgul et al., 2015), and self-reported poor health conditions (Yiengprugsawan et al., 2009).

Occupation, was rarely used as a socio-economic measure in Thai studies. None of the research linked the occupation structure among Thai population to the occupational hierarchy in developed Western countries. The Thai occupation structure is not strictly hierarchical, for example, it is difficult to confirm that non-professional occupations have a higher position than agriculture occupations, as many individuals in agriculture occupations have their own land. In addition, older people might be miscategorised when they used to work before the data were collected (Vapattanawong et al., 2008; Zimmer and Amornsirisomboon, 2001). However, there were studies, which reported the association between occupation and health status. Different occupation classifications were used in each study. Therefore, the results were different depending on occupation classification and health outcomes (Seubsman et al., 2011; Zimmer and Amornsirisomboon, 2001).

Most of the Thai studies on social inequalities in general health shared common strengths, with studies analysing data from large nationally representative samples, and reporting associations that were adjusted for demographic factors and urban/rural status. However, most of them did not consider health-related behaviours and neighbourhood characteristics.

To summarise, socio-economic gradients in health among Thai adults exist for a range of non-communicable diseases. However, there is evidence for reverse gradients in relation to overweight, obesity, diabetes and hypertension, which were relatively more concentrated among higher socio-economic groups, especially among men. These findings might be explained by social and cultural values in Thailand: Not

only have men that are more affluent better access to food and less physically demanding jobs, overweight is associated with prosperity among Asian men whereas there is social pressure on women to be thin.

Area-level socio-economic position and general health

The evidence on area-level socio-economic position and health among the Thai population is limited. Three studies used area socio-economic position to assess inequalities in health status/outcomes. Faramnuoyphol and Vapattanavong (2005b) used the district socio-economic index, which is calculated from five district socio-economic indicators that are associated with provincial average income (proportion of the adult population working in agriculture, proportion of the adult population with no high school education, proportion of households in urban areas, proportion of households having a telephone, and the proportion of households having a car). All information, including socio-economic and demographic characteristics and death registries of each district in the year 2000 were used to compare the Standardized Mortality Ratio (SMR) between districts. The results showed that districts which were in the second richest quintile (quintile 4) had the highest all-cause SMR, while districts which were in the first quintile had the lowest all-cause SMR (Figure 2-1). It could be hypothesized that the highest mortality in the fourth quintile was caused by a combination of both communicable and non-communicable diseases. The double burden of diseases is a problem in parts of the developing world, which face increases in non-communicable diseases while communicable diseases still persist (Faramnuoyphol and Vapattanavong, 2005b). In addition, the study also showed SMR for different diseases by district socio-economic position. The socio-economic differences in mortality rates had different patterns depending on the cause of the mortality (Figure 2-2). There were reverse socio-economic gradients in SMR for AIDS, cerebro-vascular disease, ischemic heart disease, and COPD. However, the study

compared mortality rates between district socio-economic position by descriptive statistics and did not consider other potential confounders, such as health-related behaviour.

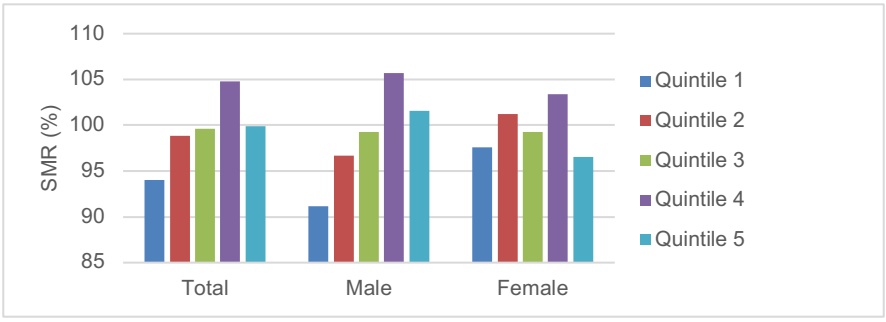

Figure 2-1 all-cause Standard Mortality Rate (SMR) by district socio-economic index (Faramnuoyphol and Vapattanavong, 2005b)

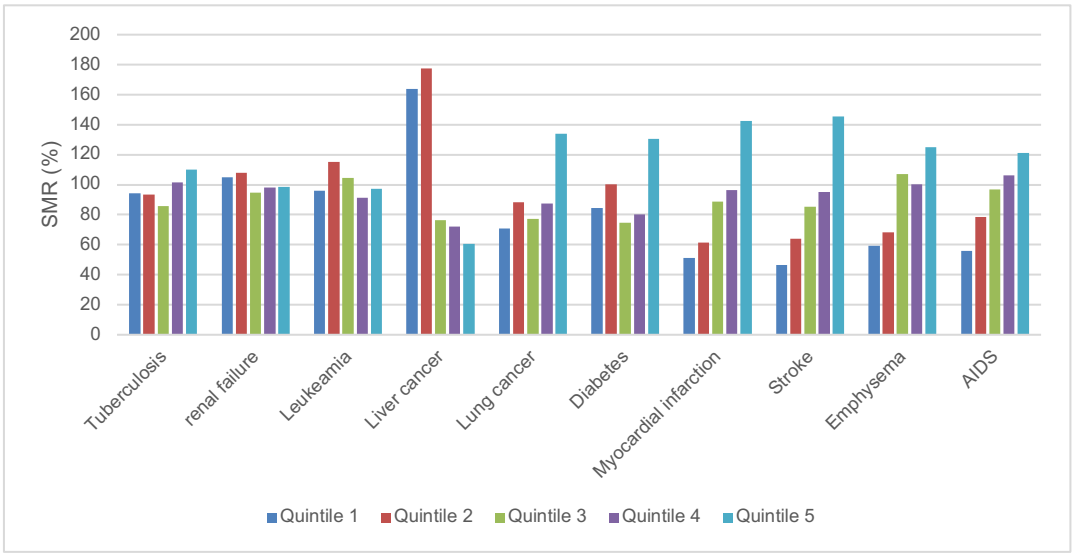

Figure 2-2 Standardized Mortality Ratios of various diseases by district socio-economic index (Faramnuoyphol and Vapattanavong, 2005b)

Petcharoen et al. (2006) conducted an ecological study, assessing the association between mortality rate from cardiovascular disease and provincial socio-economic position. Provincial socio-economic position is a composite index, including income per capita, GINI coefficient, proportion of residents with professional and managerial occupations, percentage of population with more than primary school education and percentage of home ownership. The results showed that provincial socio-economic

position was positively associated with mortality rate from cardiovascular disease. Therefore, provinces with high provincial SEP had a higher death rate from cardiovascular disease.

Angkurawaranon et al. (2013) conducted an ecological study to evaluate the association between provincial characteristics and non-communicable disease mortality. The results showed that high provincial population density was negatively associated with all-cause mortality rate but positively associated with cardiovascular mortality rate, cerebrovascular mortality rate and malignant neoplasm mortality rate; Increases in population density decreased all-cause mortality rate but increased cardiovascular mortality rate, cerebrovascular mortality rate and malignant neoplasm mortality rate. In addition, proportion of population living in urban area and the number of doctors per population were also positively associated with all mortality outcomes. On the other hand, the province average monthly household income was negatively associated with all mortality outcomes. These two study benefit from the use of national data and controlling for area demographic structure, number of doctors per population (only in Angkurawaranon et al. (2013)), area-level health-related risk factors (only in Petcharoen et al. (2006)), and urbanisation.

Although there were only three studies on area-level SEP and general health, many studies assessed geographic or area differences in health outcomes without referring to area characteristics. Regional differences in health outcomes, including mortality rate, (Faramnuayphol et al., 2008; Faramnuoyphol and Vapattanavong, 2005a; Odton et al., 2010; Vapattanawong et al., 2008), stroke (Hanchaiphiboolkul et al., 2011), cardiovascular risk factors (Chongsuvivatwong et al., 2010), and various self-reported health outcomes were reported (Tangcharoensathien et al., 2006; Yiengprugsawan et al., 2007). The data from Health Information System Development Office (2015)

also showed that the mortality rate differed by provinces and cause of mortality. Figure 2-3 shows the geographical distribution of province standardised mortality ratio for stroke, HIV and oral cancer in 1998 – 2008.

Living in an urban area was also related with health differences, and relationships differed for various health outcomes. Yiengprugsawan et al. (2013) conducted a review of 16 studies which used data from Thai Cohort Studies. The review concluded that living in an urban area was a strong geographic factor associated with health outcomes. Living in urban area was associated with both positive (increase in height) and negative health outcomes (obesity and depression). In addition, people living in urban areas were more likely to have unhealthy eating habits, low physical activity and low social capital. Living in urban area was not only associated with obesity but also associated with overweight and diabetes (Aekplakorn, 2009; Aekplakorn et al., 2007a; Aekplakorn et al., 2011; Aekplakorn et al., 2007b; Aekplakorn et al., 2014; Aekplakorn and Mo-suwan, 2009; Jitnarin et al., 2010).

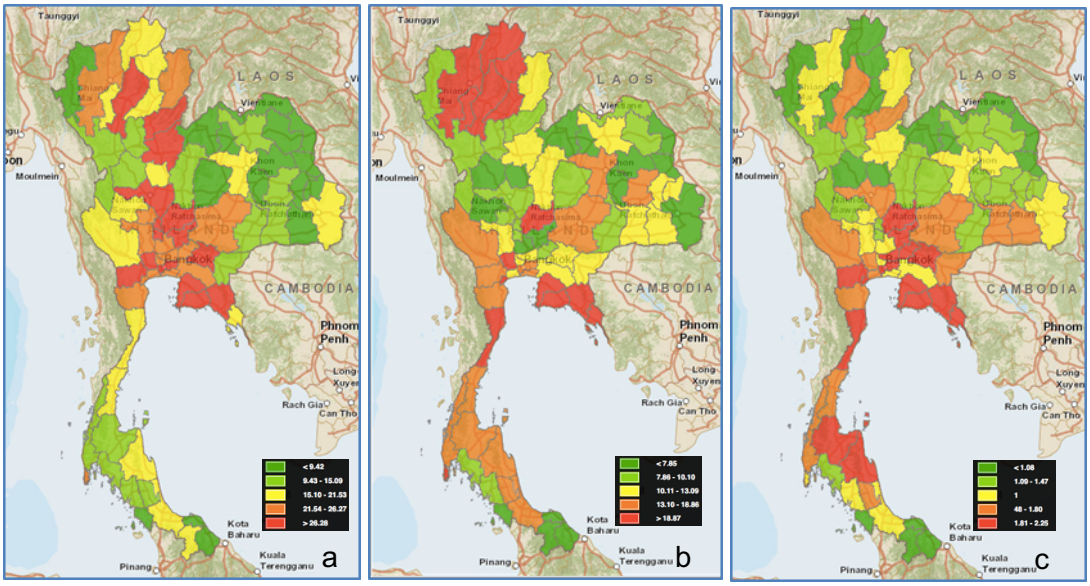

Figure 2-3 Geographical distribution of province standardized mortality ratio for (a) Stroke (b) HIV (c) Oral cancer in 1998 – 2008 (Health Information System Development Office, 2015).

In summary, the evidence on area-level SEP and health among the Thai population is limited. The studies confirmed that geographical area and neighbourhood characteristics were related to health; however, the associations were inconsistent and varied by area-level measures and health outcomes used. Moreover, none of the studies used multilevel models and considered the concurrent effect of both individual- and area-level SEP on health.

Overall, a limited number of Thai studies have showed a relationship between health and socio-economic position at both individual- and area-levesl. However, the direction of these associations was not consistent depending on the health measures assessed.

2.3 Research on oral health inequalities and social gradients in oral health

As with general health, oral health is related to socio-economic position. There are oral health inequalities and a social gradient in oral health (Morita et al., 2007; Sabbah et al., 2007; Steele et al., 2015; Watt et al., 2015; Watt and Sheiham, 1999). “Social gradients occur for all oral conditions, and appear to be persistent over time.” (Kwan and Petersen, 2010). Many studies have reported associations between various socio-economic factors and a range of oral health outcomes but the size and significance of the associations vary depending on indicators of socio-economic position used and oral health measures.

2.3.1 Individual- or household-level socio-economic position and oral health

Associations between individual-level socio-economic position and oral health have been widely reported. Various oral health outcomes, including dental caries, periodontal status, tooth loss and self-rated oral health, are socially patterned (Boillot et al., 2011; Borrell and Crawford, 2012; Gabardo et al., 2013; Klinge et al., 2005; Schwendicke et al., 2015; Steele et al., 2015).

Dental caries

Two recent systematic reviews concluded that lower socio-economic position, measured as education, income and occupation, was statistically significantly associated with a higher risk of dental caries (Costa et al., 2012; Schwendicke et al., 2015). In addition, the meta-analysis showed that people with low levels of education were 50% more likely to have dental caries and 30% more likely to have caries experience (DMFT/dmft>0) compared to people with high levels of education. Caries prevalence and caries experience were 29% and 40% higher in people with low

compared to high income and also 30% and 21% higher in people from low compared to high occupational class. However, these reviews have some limitations. Costa et al. (2012) reviewed evidence on adults only while the systematic review from Schwendicke et al. (2015) included evidence on all age groups together. Both reviews focused only on the difference between high and low socio-economic groups, and did not examine social gradients in dental caries.

Periodontal disease

Social gradients are reported also for periodontal disease. People with higher social status have less periodontal disease than those with lower social status (Blas et al., 2010; Borrell and Crawford, 2012; Do et al., 2003; Sabbah et al., 2007; Slade et al., 2007; Steele et al., 2015; Thomson et al., 2004). Five systematic reviews have assessed the association between socio-economic position and periodontal diseases. Firstly, Klinge et al. (2005) conducted a systematic review of 47 studies. This review found both significant and non-significant associations between socio-economic position and periodontal outcomes. The inconsistent results might be due to different study designs. Most cross-sectional studies (29 out of 36) found significant associations while only half of case-control and longitudinal studies (6 out of 11) reported significant associations. In 2011, Boillot and colleagues conducted a systematic review and the only meta-analysis to assess the effect of education on chronic periodontitis. The meta-analysis showed that individuals with low educational attainment were 86% more likely to have chronic periodontitis than individuals with higher educational attainment (Boillot et al., 2011). However, education was the only SEP measure considered in this review. Bastos and colleagues (2011) also conducted a systematic review on inequalities in periodontal outcomes. Twenty-nine studies conducted among Brazilians from 1999-2008 were included in the review.

This review also concluded that individuals belonging to lower socio-economic groups experienced poorer periodontal health. This study included all age groups and used various periodontal outcomes, including gingivitis and periodontitis. However, the review covered only studies conducted among Brazilians (Bastos et al., 2011). Borrell and Crawford (2012) reviewed studies in 2002-2009 and concluded that there was a relationship between periodontitis and lower SEP measures regardless of the SEP indicator used. This study reviewed the association between periodontal diseases and various individual SEP measures, including education, income, wealth and ethnicity. More recently, Schuch and colleagues (2017) conducted a systematic review of eight studies and concluded that low socio-economic position in early life was associated with periodontal disease in adulthood.

Tooth loss

Tooth loss was also shown to be related to socio-economic factors such as level of education, income and occupational class. Adults with higher education, occupational class and income levels tend to have fewer missing teeth than those who are more disadvantaged (Bernabé et al., 2010; Burt et al., 1990; Crocombe et al., 2012; Elani et al., 2012; Guarnizo-Herreño et al., 2013; Guiney et al., 2011; Morita et al., 2007; Müller et al., 2007; Sanders and Spencer, 2004; Seerig et al., 2015; Shen et al., 2013; Thomson, 2012). In the United States and the United Kingdom, several studies reported social gradients in total tooth loss and edentulousness. People belonging to lower socio-economic groups are more likely to have total tooth loss than people with higher SEP (Kwan and Petersen, 2010; Shen et al., 2013; Steele et al., 2015; Tsakos et al., 2011). Furthermore, Gülcan et al. (2015) analysed data from two cohort studies from Norway and Sweden. The results showed that lower education and not working were related with more tooth loss. Seerig et al. (2015) conducted a systematic review

of 22 studies in order to investigate the association between income and tooth loss. The review found robust evidence confirming the positive association between tooth loss and low income. The meta-analysis was conducted from 11 studies. The pooled effect showed that individuals with low income were 2.5 (95%CI 2.1-3.0) times more likely to have tooth loss.

Self-rated oral health

Not only clinical oral health outcomes but also self-rated oral health is related with SEP. Many studies report socio-economic inequalities and a gradient in self-rated oral health. Individuals with low socio-economic position were more likely to report poor perceived oral health than those with higher socio-economic position (Aida et al., 2011; Bernabé et al., 2010; Gabardo et al., 2013; Sabbah et al., 2007; Sanders et al., 2006; Sanders and Spencer, 2004; Tsakos et al., 2011).

2.3.2 Area-level socio-economic position and oral health

Differences in oral health status are also found between countries, as well as between different areas within countries (Bernabe et al., 2009; Borrell et al., 2006a; Borrell et al., 2006b; Do, 2012; Hobdell et al., 2003; Müller et al., 2007; Williams, 2014) Various oral health measures and area-level characteristics were used to assess the relationships between contextual factors and oral health (Locker and Ford, 1994).

Dental caries

Hobdell et al. (2003) and Do (2012) conducted ecological studies and found that Human Development Index (HDI), Gross Domestic Product (GDP) and Gini coefficient were positively associated with DMFT among children. Do (2012) also found that caries experience in countries with higher HDI had sharply declined, but this was not true for countries with lower HDI. These two studies used however fairly old data. Hobdell et al. (2003) used data from the 1990s and Do (2012) used baseline data from 1980. More recently, Bernabe et al. (2009) conducted an ecological study among eighteen high income countries. The results showed that absolute income, defined by gross domestic product (GDP) and gross national income (GNI), was not associated with dental caries. However, income inequalities, defined by Gini coefficient were positively associated with DMFT and number of filled teeth. This study benefited from analysing the components of the DMFT, however, it included only 18 rich countries.

Periodontal disease

The aforementioned study by Hobdell et al. (2003) also found that countries with a higher Human Development Index had lower mean levels of periodontal disease, measured via the Community Periodontal Index (CPI). Periodontal disease was also negatively associated with mean years of schooling and positively associated with the Gini coefficient (Hobdell et al., 2003). Sabbah et al. (2010) found a statistically significant association between income inequality, measured by the Gini coefficient, and periodontal diseases, defined by CPI. Hobdell et al. (2003) analysed data from 44 countries, while Sabbah et al. (2010) used data from only 17 rich countries. In addition, two studies from the United States reported associations between

neighbourhood socio-economic position and chronic periodontitis, with individuals living in low socio-economic position neighbourhoods being more likely to have chronic periodontitis (Borrell et al., 2006a; Borrell et al., 2006b). The associations between neighbourhood SEP and periodontitis were adjusted for individual-level SEP but not for risk factors.

Tooth loss

Müller et al. (2007) conducted a review on tooth loss and edentulousness among European adults and found that there was a difference in prevalence of edentulousness between geographic regions within countries. In addition, a recent study by Jagger et al. (2013) found a significant positive association between the prevalence of edentulousness and area-based deprivation quintile among Scottish adults.

In summary, there are clear relationships between oral health outcomes and socio-economic position. Regarding individual-level socio-economic position, better oral health outcomes i.e. less dental caries, better periodontal health status, less tooth loss and better self-reported oral health, were associated with higher individual-level SEP. Regarding area-level socio-economic position, individuals living in more advantaged areas also experienced better oral health outcomes. However in relation to dental caries experience associations varied depending on which SEP and outcome measures were used.

2.3.3 Multilevel studies on oral health outcomes

Multilevel modelling is increasingly used in oral health studies in order to simultaneously assess the potential effects of both individual- and area-level SEP on oral health outcomes.

Multilevel studies in oral health were identified from systematic searching using the MEDLINE (Ovid version) database. Only studies which used outcomes of interest, including dental caries, periodontal disease and tooth loss, were included. Twenty individual studies were included in this review (study details are presented in Appendix 1).

Dental caries

Six multilevel studies on dental caries were identified. Five out of six used clinical measures of dental caries (Bower et al., 2007; Celeste et al., 2011; Celeste et al., 2009; Choi and Lee, 2011; Tellez et al., 2006) and one used self-reported measures (Ardila et al., 2016).

Three out of six studies were conducted in high-income countries. Firstly, Tellez and colleagues (2006) conducted a study among low-income African-American in Detroit, United States. The analysis showed variations of severity of dental caries between neighbourhoods before adjusting for area characteristics. Caries levels were associated with all individual-level characteristics, and also with the number of churches and grocery stores in the area. This study controlled for a wide range of individual characteristics, including demographic, SEP, and health-related behaviour measures. However, the findings of this study may not be generalisable to the national population. Secondly, Bower et al. (2007) conducted a study among a representative sample of more than 600 Scottish adults aged 16 years and over, using data from the

1998 Adult Dental Health Survey in the United Kingdom. The analyses showed that area deprivation (measured via the Carstairs Index) was not independently associated with having unsound teeth. However, household income was significantly associated with having unsound teeth and a household income gradient was found. Lastly, Choi and Lee (2011) conducted a study among a nationally representative sample in South Korea. The analyses showed statistically significant associations between dental caries experience and both individual- and contextual-level characteristics. This was a good quality study, however, the outcome measure was the dichotomised DMFT index. Dichotomising variables causes several problems, including loss of information, reduced statistical power and increased risk of false positive results (Altman and Royston, 2006).

Three studies were conducted in middle-income countries. Two studies were conducted in Brazil using data from the oral health survey in Brazil in 2002-2003 (SBBrazil). Both studies reported the association between income inequality and oral health among Brazilian adults aged 35-44 years; the number of decayed teeth was positively associated with the Gini coefficient. The association and variation between municipalities remained significant when adjusted for individual factors and other covariates (Celeste et al., 2011; Celeste et al., 2009). Both studies focused on the association between Gini coefficient and oral health outcomes and did not report associations between individual-level SEP and oral health. Their strengths include the use of large national representative samples and clinical oral health outcomes. The last study, Ardila et al. (2016) conducted a study among 6,440 adults belonging to minority ethnic groups in Columbia. The multilevel analyses showed that adults who were older age, had higher education and last dental visit more than one year, and lived in high GDP state were more likely to reported dental caries. The study also found significant variation in the prevalence of self-reported dental caries between

states. The strengths of this study were the large sample size and use of nationally representative data. In addition, oral health related behaviours, dental attendance and unmet dental need were included in the fully adjusted model. There were also some limitations: The sample population only included minority ethnic groups, and the dental caries outcome was based on self-reporting.

In summary, a limited number of multilevel studies on dental caries in adult populations was identified. The associations between individual-level socio-economic position and dental caries were consistent. Independent associations between area-level socio-economic position and dental caries were also found but were somewhat less clear.

Periodontal status

Five studies on periodontal status were available. Only one study was conducted in a high-income country. The aforementioned study by Bower et al. (2007) using the 1998 Adult Dental Health Survey in the United Kingdom showed that there was significant variation in periodontal disease (periodontal pockets ≥ 4mm) between postcode sectors. However, neither area deprivation nor individual socio-economic factors were associated with periodontal disease. The only factor that was significantly associated with periodontal disease was age.

Four studies were conducted in middle-income countries; of these three were conducted in Brazil using a nationally representative sample. Celeste et al. (2011) found that periodontal conditions, including clinical attachment loss > 8mm and gingivitis, were not associated with Gini index after accounting for individual-, and contextual-level characteristics and variation between neighbourhoods. Vettore et al. (2013) conducted a study among 35-44-year-old Brazilian adults. The multilevel

analyses showed education and family income gradients in periodontal disease after adjusting for area-level factors. Further, periodontal disease varied between cities. Of the area-level measures, the percentage of smokers, level of integration and the Gini coefficient were associated with periodontal disease. This study has several strengths: large sample size and nationally representative data and use of two clinical periodontal outcomes (periodontal pocket depth and clinical attachment loss). However, this study also has a limitation. Oral health-related behaviours at the individual level, such as smoking, were not considered in the analysis. Another study from Brazil was conducted among older people aged 65-74 (Dalazen et al., 2016). Three clinical periodontal outcomes were used; having dental calculus, shallow periodontal pockets (3-5mm) and deep periodontal pockets (≥6 mm). The prevalence of poor periodontal conditions was higher among male, non-white older people with low education. Only one contextual factor, population coverage by Family Health Strategy, was significantly associated with having shallow and deep periodontal pockets. The area level variance was not reported. Limitations of this study were the lack of adjustment for age and oral health-related behaviours (i.e. smoking,) and that the area level variance was not reported. Lastly, Sun et al. (2016) conducted a study among a large nationally representative sample of Chinese adults aged 35-44 and 65-74 years. The crude multilevel model showed that the number of teeth with periodontal pockets ≥4 mm and number of teeth with loss of attachment ≥4 mm were associated with almost all individual-level factors in both age groups. Regarding are-level factors, the number of teeth with periodontal pockets ≥4 mm was significantly associated with the proportion of smokers in the area only among age group 65-74. Additionally, a higher number of teeth with loss of attachment ≥4 mm was significantly associated with higher GDP per capita, higher public health expenditure, lower the dentist per population ratio and lower proportion of minority ethnic groups in both age

groups. This study did not report random effects, including area-level variance for the fully adjusted model.

Similar to dental caries, only few multilevel studies on periodontal disease in adult populations have so far been conducted. Existing studies found variations in periodontal disease between areas, but associations between periodontal disease and individual-level SEP were more consistent than relationships with area-level SEP.

Tooth loss

Tooth loss was a frequently used oral health outcome for adults and older people. Thirteen multilevel studies on tooth loss are available; of which seven used a clinical measure (Bower et al., 2007; Celeste et al., 2011; Celeste et al., 2009; Chalub et al., 2016; Goulart and Vettore, 2016; Koltermann et al., 2011; Moreira et al., 2010) and six used a self-reported measure (Aida et al., 2011; Barbato et al., 2015; Bernabé and Marcenes, 2011; Ito et al., 2015; Sanders et al., 2008; Turrell et al., 2007).

Of the studies that used clinical measures, one study was conducted among a representative sample of Scottish adults and reported individual-level socio-economic gradients in the number of functional teeth. Area deprivation was negatively associated with the number of functional teeth, however, the association became non-significant after adjusting for individual-level factors. The six remaining studies were conducted in Brazil (Celeste et al., 2011; Celeste et al., 2009; Chalub et al., 2016; Goulart and Vettore, 2016; Koltermann et al., 2011; Moreira et al., 2010). The analyses of the nationally representative sample of Brazilian adults showed edentulousness and having a non-functional dentition were independently associated with individual- and area-level SEP. Adults with low SEP who were living in less privileged neighbourhoods experienced more tooth loss. There was evidence of

education and income gradients in tooth loss (Chalub et al., 2016; Goulart and Vettore, 2016; Koltermann et al., 2011; Moreira et al., 2010). Regarding area-level factors, tooth loss was significantly associated with the number of dentists (Moreira et al., 2010), population size (Moreira et al., 2010), municipal income (Celeste et al., 2011), mean municipal schooling (Koltermann et al., 2011), municipal HDI (Chalub et al., 2016), urban/rural status, and fluoride water supply (Chalub et al., 2016; Koltermann et al., 2011). Although three studies found no significant association between tooth loss and Gini coefficient (Celeste et al., 2011; Celeste et al., 2009; Chalub et al., 2016), Goulart and Vettore (2016) reported that non-functional dentition was associated with increasing of Gini index. The strength of studies from Brazil was a large nationally representative sample. None of the Brazilian studies considered oral health related-behaviour factors, such as oral health care and smoking.

Six studies considered self-reported measures of tooth loss; most of them were conducted in high-income countries, including Australia (Sanders et al., 2008; Tellez et al., 2006), Japan (Aida et al., 2011; Ito et al., 2015) and United States (Bernabé and Marcenes, 2011). Two large studies from Australia were conducted among adults aged 43-57 years old living in Adelaide, Australia. Adults who belonged to low socio-economic groups and lived in socio-economically deprived neighbourhoods experienced more tooth loss compared to their counterparts (Sanders et al., 2008; Turrell et al., 2007). Oral health-related behaviours were not included in the analyses in either study. Of the two studies from Japan, one analysed data of a representative sample of older adults from Aichi prefecture (Aida et al., 2011) and another analysed data of a representative sample of older adults from twelve prefectures across Japan (Ito et al., 2015). Both studies also reported education and income gradients in non-functional dentition and edentulousness. Regarding neighbourhood factors, Aida et al. (2011) found a positive association between Gini coefficient and reporting less than

20 teeth remaining, and Ito et al. (2015) found a negative association between community income and edentulousness. In addition, both studies reported variation in tooth loos between municipalities. The two studies shared several limitations; both used self-reported oral health outcomes and self-administered questionnaires, which had low response rates. Only one oral health-related behaviour, smoking status, was included in the models.

In the United States, Bernabé and Marcenes (2011) also found education and household income gradients in tooth loss. Regarding contextual-level factors, tooth loss was significantly associated with Gini coefficient and percentage of residents receiving fluoridated water. The limitations of this study are use of a self-reported outcome and a low response rate (53%). However, the study used a large sample population, which had only small differences in demographic status compared with national population. In Brazil, Barbato et al. (2015) found significant variation in tooth loss between neighbourhoods. Tooth loss was significantly associated with area socio-economic position, a period of fluoridated water, and all individual-level factors. Income and education gradients were also found: Individuals with low education and low income living in a poor area were more likely to report <10 teeth in at least one arch or to be edentulous. Although a large sample was used, the sample population was limited to Southern Brazil. This study considered the length of living in the same area, which might affect the influence of contextual level factors on oral health, however health-related behaviours or dental utilisation were not considered.

In summary, tooth loss was independently associated with both individual- and area-level socio-economic position. All studies reported consistent associations between tooth loss and socio-economic position at individual-level and most of the studies reported at least one area-level factor to be significantly associated with tooth loss. In

addition, the direction of the associations was consistent; individuals with high SEP and living in privileged neighbourhoods experienced less tooth loss.

In conclusion, multilevel studies provided evidence of independent effects of individual- and contextual- level factors on oral health outcomes. The number of dental studies using multilevel analysis is still insufficient. Most of the studies reported variations of oral health status between areas. However, the effect of area-level characteristics on oral health is still inconclusive. Significant and non-significant associations varied depending on SEP measures, oral health outcomes and neighbourhood definition used. On the contrary, the effect of individual-level characteristics was more consistent; most studies reported negative associations between SEP and oral diseases.

2.3.4 Evidence on social inequalities in oral health in Thailand

Along with social and economic developments in Thailand since the 1970s, a Universal Health Coverage Scheme was introduced in 2002. This national policy widened coverage for the all population who had never been covered by any health insurance, and also incorporated those in other insurance schemes including the Civil Servant Medical Benefit Scheme (CSMBS) and Social Security Scheme (SSS). Although the different health schemes have different health benefits, all of them cover the costs of all basic dental treatment, including filling, tooth cleaning, and extractions (Jongudomsuk et al., 2015). Over the last 40 years considerable improvements have taken place in the overall oral health status of Thai adults (Bureau of Dental Health, 2018). Findings from Thai National Oral Health Surveys show increasing numbers of filled and retained teeth over this period. Among 35-44-year olds, the prevalence of adults with a functional dentition (>=20 teeth) increased from 92.7% in 1984 to 98.1% in 2017. Among older adults aged 60-74 years there was also an increase from 47.2% in 1984 to 56.1% in 2017 (Bureau of Dental Health, 2018).

As mentioned earlier, the associations between health and socio-economic position among Thai adults were not consistent and varied by the health outcomes and socio-economic measures included in the analysis. This following section reviewed studies on the association between oral health status and individual- and area-level socio-economic position among Thai adults.

2.3.4.1 Individual- or household-level SEP and oral health

The following section will review the limited number of the studies on outcomes of interest, including dental caries, periodontal disease, tooth loss, and self-reported oral health outcomes.

Dental caries

Only one study investigated the association between individual socio-economic position and dental caries in Thailand. Nicolau et al. (2000) conducted a cross-sectional study among 549 older people aged 60-74 years, in Chiang Mai, Thailand. The results showed that older people who had low education (≤4 years of education) and low income (≤1,500 THB equivalent to ≤30 GBP) were 2.4 and 1.9 times more likely to have root caries compared to those who had high education (>4 years of education) and high income (>1,500 THB equivalent to >30 GBP). This study has several limitations. Firstly, this study was conducted among a small sample, which was recruited from only one province in Thailand and does not represent the national population. Secondly, the education and income measures consisted of only two categories. Therefore, the social gradient could not be investigated. Lastly, some possible risk factors, such as smoking and oral health care behaviours, were not included in the study. However, the strengths of this study were using a clinical dental caries measure and being the only study that assessed the association between socio-economic position and dental caries among Thai adults.

Periodontal disease

Two studies reported on associations between socio-economic position and periodontal diseases. Torrungruang et al. (2005) conducted a study among 2,005 senior and retired employees aged 50-73 of Electricity Generating Authority of Thailand (EGAT). The results showed that low education and income were associated with chronic periodontitis. Individuals with high education (above high school) were 0.4 times less likely to have severe periodontitis (clinical attachment loss ≥4 mm) compared to those who had low education. The results also showed an income gradient in severe periodontitis, however, the association became non-significant in the fully adjusted model. Torrungruang et al. (2009) conducted another study among

453 employees aged 39-59 of EGAT. The results were similar to the previous study. Moreover, employees with high education (above high school) and high income (≥15,000 USD/year) were 0.4 and 0.6 times less likely to have chronic periodontitis. However, the association between income and chronic periodontitis became non-significant in the fully adjusted model. These two studies shared the same limitations. They were conducted only among small samples recruited from a specific population, therefore the results could not be generalised to the whole Thai population. In addition, crude categories were used for education and income measures. However, there were several strengths. Periodontal disease was clinically assessed in both studies. Also, the associations were adjusted for oral health related-behaviours, including smoking status and alcohol consumption and also adjusted for a general health condition (diabetes).

Tooth loss

Inequalities in tooth loss were also reported. Chatrchaiwiwatana and colleagues (2012) conducted a study among 457 Thai adults, working in industrial estates. The results showed that individuals with low education background (below bachelor degree) were three times more likely to report tooth loss due to dental caries compared to those with higher education background (≥bachelor degree). This study was conducted among a small sample recruited from industrial estates. Although the sample size was calculated, the results could only represent the workers in that area and could not be generalised to the national population. Education was a binary measure, so the existence of a gradient could not be investigated. Oral health-related behaviours were not considered.

Recently, Srisilapanan and colleagues (2016) conducted a study using data from the Survey of Older Persons in Thailand 2007, which is a national representative survey

conducted by the National Statistics Office (NSO) of Thailand. Over 30,000 Thai elders were included in the study. The oral health measure was self-reported number of remaining teeth. Answers were categorized into two groups; 0 to 19 and 20 or more remaining teeth. The study reported similar results to previous studies. In the fully adjusted model, elders with low education (<7 years of education), and low family income (<400 GBP/year), and those who did not own luxury goods were 1.4, 1.1, and 1.2 times more likely to have 19 or fewer teeth remaining compared to those with high education (≥7 years of education), high family income (≥400 GBP/year), and owning luxury goods. The main strength of this study was using a large national representative sample. However, the various socio-economic measures all consisted of only two categories. Additionally, the oral health outcome was a self-reported measure and oral health-related behaviours or dental attendance were not included in the analyses.

Another study, by Yiengprugsawan et al. (2011a), analysed data from the Thai Cohort Study (TCS), which is a large longitudinal cohort study among 87,134 adults who were distance-learning students of Sukhothai Thammathirat Open University in Thailand. Participants were asked to complete 20 pages questionnaire. The oral health outcome was self-reported number of teeth. Answers were dichotomised into two categories; <20 and ≥20 teeth remaining. Three individual socio-economic measures were used in this study: education, monthly income and household assets. Household assets is a standardised validated measure used by Thai National Statistical Office, which is based on ownership of general domestic items, such as microwave oven, telephone, and washing machine. Bivariate analysis showed that reporting less than 20 teeth remaining was significantly associated with education, income, and being a lifetime urban resident. The regression analyses from the baseline data showed education and income gradients in reporting less than 20 teeth remaining; individuals with low

education and low income were more likely to report less than 20 teeth. This study had several strengths. The associations were adjusted for age, sex, smoking status, soft drink consumption, and standardized socio-economic measures were used. Although this study was conducted among a large sample, all participants were students in one Open University. Another limitation was the use of a self-reported oral health outcome.

Self-reported oral health outcomes

Yiengprugsawan et al. (2011b) also analysed the data from Thai Cohort study. The results showed income and wealth gradients in Oral Health-Related Quality of Life. Being older, female, on a low income or less educated was associated with adverse oral impacts, including discomfort in speaking, swallowing, chewing, social interaction and pain.

Other studies using data from the Thai Health and Welfare Survey (HWS) 2006 reported similar results. A stratified two stage sample method was used to recruit over 37,000 Thai adults age 15 and over from all 76 provinces in Thailand. All information was collected via a structured interview. Somkotra (2011) found that female elders with low education and low socio-economic position were more likely to report extreme or severe oral health problems during the past month compared to those from a more advantaged socio-economic background. In addition, the results of this study also suggested a socio-economic gradient in self-reported poor oral health, which was however not statistically significant.

In brief, although a limited number of Thai studies were found, inequalities and social gradients in oral health among Thai adults have been previously reported and were consistent with the evidence from other countries. Overall, individuals belonging to

lower socio-economic groups experienced more oral health problems. Poor oral health outcomes, such as root caries, periodontal disease, having less than 20 teeth and poor self-rated oral health, were concentrated among the elderly, females, less educated, and those on low incomes (Chatrchaiwiwatana et al., 2012; Nicolau et al., 2000; Somkotra, 2011; Srisilapanan et al., 2016; Torrungruang et al., 2009; Torrungruang et al., 2005; Yiengprugsawan et al., 2011a; Yiengprugsawan et al., 2011b).

2.3.4.2 Area level SEP and oral health

Although none of the Thai studies reported on the relationship between SEP at the regional level and oral health outcomes, associations between geographic region and oral health outcomes were reported without referring to area characteristics. Most of the Thai studies divided Thailand into five regions, including Northeast, North, South, Central, and Bangkok. The poor population is concentrated in the North-eastern, Northern and Southern regions and 90% of the poor are living in rural areas (Jansen, 2001). Therefore, oral health status might differ between regions and urban/rural areas. Figure 2-4 shows that the provinces with a high Poverty Headcount Ratio (PHR) were concentrated in the Northeast and the North from 1988 to 2002. Until 2016, overall PHR for all regions has decreased; but PHR still was lowest in Bangkok (1.4%) and highest in North-eastern regions (13.0%).

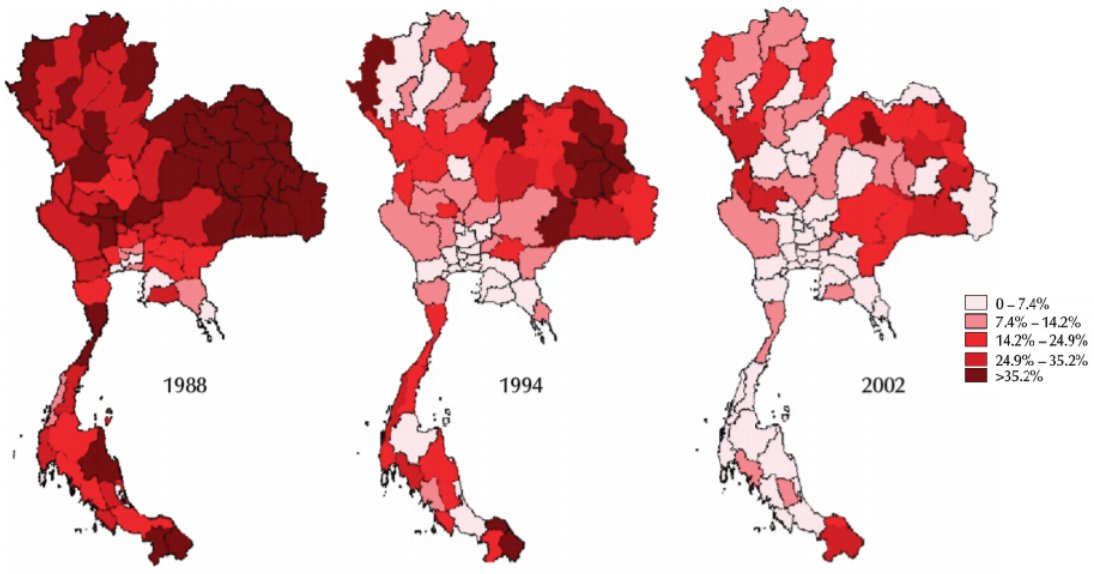

Figure 2-4 Poverty Headcount Ratio by province, Thailand, in 1988, 1994 and 2002 (Jitsuchon and Richter, 2007)

As mentioned above, the poorer population is concentrated in the North-eastern and Northern regions and most of the poor are living in rural areas. As in many other countries, better oral health outcomes are found among city dwellers or urban populations. Chatrchaiwiwatana et al. (2012) reported that industrial workers who lived outside the Central region were almost two times more likely to have tooth loss due to caries than those who lived in the Central region (fully adjusted OR=2.0; 95% CI=1.3-3.0). Somkotra (2011) also found that North, North-east, and South residents were more likely to report worse oral health than Central residents.

In contrast, Yiengprugsawan et al. (2011a) reported that lifetime urban residents were more likely to report less than 20 teeth remaining than rural residents. Moreover, the 7th Thai National Oral Health Survey 2012 showed that adults in the Bangkok and Central regions, which have lower proportions of poor people, had higher mean DMFT scores than those who lived outside the Central region of the country. In addition, the results also showed that mean DMFT scores were higher among populations who lived in municipal compared to rural areas (Figure 2-5) (Dental Health Division, 2013b).

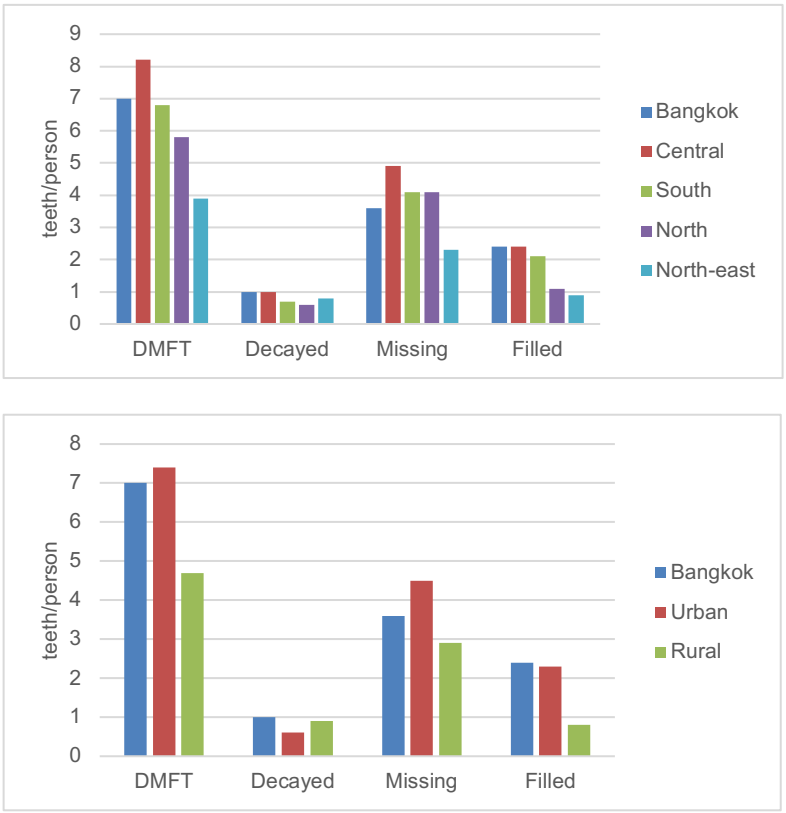

Figure 2-5 Caries experience among Thai population aged 35-44 (a) by regions (b) by urbanization (Dental Health Division, 2013b)

In conclusion, associations between individual and area-level socio-economic position and oral health in Thailand vary between studies, depending on the oral health and socio-economic measures used. At the individual level, those with higher socio-economic position, education and income were consistently more likely to have better oral health status. However, the literature on associations between area-level characteristics, including urbanization, and oral health was inconclusive. Some studies reported that residents in rural or poorer areas had poorer oral health (Chatrchaiwiwatana et al., 2012; Somkotra, 2011) while some studies reported the opposite (Dental Health Division, 2013b; Yiengprugsawan et al., 2011a).

Various oral health outcomes were used in the studies. However, few studies used clinical measures. The only three studies that used clinical oral health measures were conducted among small samples. Common socio-economic measures used in the

studies were education and income. None of the previous studies assessed the influence of area level socio-economic measures on oral health outcomes among the Thai population.

In summary, very limited evidence exists on associations between socio-economic position at both individual- and area-level and oral health outcomes among the Thai adult population. In addition, directions of the associations were not consistent and varied between different studies, oral health outcomes and SEP measures assessed.

2.4 Gaps in the literature

Inequalities in health and oral health are a global public health challenge. To tackle inequalities in health and oral health, Government and policy makers need an update evidence on inequalities in health and oral health status and the factors associated with the inequalities. The evidence will help policy makers to understand the situation and to develop effective policies.

The available evidence on inequalities in oral health among Thai adults is limited, inconsistent in nature and has not explored in any detail the underlying determinants of inequalities. There are only a few studies on oral health inequalities among the Thai adult population. Most of the previous studies used socio-economic position at the individual or household level. Eight studies assessed the association between individual-level SEP and oral health outcomes. Only three out of eight studies used clinical oral health measures. However, these were conducted among small non-representative samples. The five remaining studies used self-reported oral health measures and four out of five were conducted among large samples, but only two studies used a nationally representative sample population.

Regarding area-level socio-economic position, the international literature shows the association between area-level factors and oral health in many countries (Ardila et al., 2016; Celeste et al., 2011; Jagger et al., 2013). Considerable regional inequalities in oral health have been documented for Thailand (Chatrchaiwiwatana et al., 2012; Somkotra, 2011), but none of the studies referred to area-level SEP or evaluated the association between area-level socio-economic characteristics and oral health. The direction of associations between geographic area and oral health status was not consistent between studies. Several studies were conducted on non-representative

samples, and research using clinical oral health outcomes is scarce. In addition, none of the Thai studies used multilevel models to evaluate the associations between both individual- and area-level socio-economic position and clinical oral health outcomes concurrently.

In summary, there is insufficient evidence on inequalities and social gradients in oral health among Thai adults. In addition, none of the studies assessed the association between area-level SEP and oral health. To determine the extent of oral health inequalities and social gradients in oral health among Thai adults, analyses of nationally representative data on both individual- and area level SEP and oral health is needed.

Chapter 3 Aim and objectives

3.1 Aim:

The overall aim of this research was to assess the nature and determinants of social inequalities in oral health among nationally representative samples of Thai adults aged 35-44 and 60-74 years.

3.2 Objectives:

1. To establish if social gradients exist in oral health by indicators of socio-economic position (SEP) at the individual (education, income) and area-level (regional and provincial poverty ratio), before and after adjustment for age and sex. The following oral health outcomes were assessed:
    a. Dental caries (number of decayed-missing-filled teeth, number of decayed teeth, number of filled teeth);
    b. Periodontal disease (presence of deep pockets ≥6mm);
    c. Tooth loss (presence of a functional dentition, edentulousness).
2. To establish if social gradients exist in oral health-related behaviours (frequency of tooth brushing, fluoride toothpaste usage, dental attendance and smoking status), using the same SEP indicators as before

3. Using multilevel models, to examine:
    a. The relative importance of education and income for oral health inequalities among Thai adults;
    b. Whether the observed gradients in oral health outcomes are fully or partly explained by factors operating at the individual level (oral health-related behaviours) and area level (provincial poverty ratio, dentist-population ratio, Human Achievement Index, GINI coefficient and urban/rural classification).

Chapter 4 Material and Methods

4.1 Introduction

This thesis is based on the secondary analysis of cross-sectional data from the Thai National Oral Health Survey. The analysis consisted of three main parts. The first part was predominantly descriptive, exploring the sample characteristics and social gradients in the outcomes of interest. The second part used regression analyses to examine associations between these outcomes and individual-level socio-economic position while adjusting for age and sex. Finally, the third part focused on multilevel analyses, exploring the variation in oral health between Thai provinces, and assessing the relationships between individual-, and provincial-level characteristics and oral health outcomes.

This chapter will first introduce the 7th Thai National Oral Health Survey that provided the data for the secondary analyses. Then, the measures used in this study will be described as well as the statistical analysis plan, including descriptive statistics, regression models and multi-level models.

4.2 Thai National Oral Health Survey

The Thai National Oral Health Survey series refers to cross-sectional surveys conducted every five years since 1977. At the time of writing, the latest survey was the 7th survey, which was conducted in 2012 and was used in this study. The 7th Thai National Oral Health Surveys aimed to provide information on the oral health status of the Thai population and related factors, to allow evaluation after the implementation of dental public health programmes and to provide data for international comparisons (Dental Health Division, 2013b).

4.2.1 Survey sample size

The survey methodology was based on Oral Health Survey-Basic Methods 4th edition (World Health Organization, 1997). Participants were recruited from seven age groups: 3, 5, 12, 15, 35-44, 60-74 and 80 years old. Sample size calculation was based on the prevalence of dental caries in the previous survey and calculated for each age group from the following formula (Dental Health Division, 2013b).

$$N = \frac{\text{deff.} * (Z_{\alpha})^2 \, PQ}{d^2}$$

Design effect (deff.) = 1.7
Z = standard normal variate; α = 0.05
P = prevalence of dental caries in the previous survey
Q = 1-P
d = the precision of the estimate (relative d = 5-10%)

Table 4-1 shows the target sample size for each age group.

Table 4-1 Target sample size from sample size calculation (Dental Health Division, 2013b)

Age group	Sample size					Total
	Northeast	North	South	Central	Bangkok	
3	360	456	336	264	960	2,376
5	456	720	408	456	416	2,456
12	552	360	432	336	632	2,312
15	456	240	240	240	276	1,552
35-44	552	240	240	240	128	1,400
60-74	240	240	240	240	104	1,064
80-89	72	72	72	72	24	312
Total	2,688	2,328	1,968	1,848	2,640	11,472

4.2.2 Sampling Methods

The 7th Thai National Oral Health Survey used a stratified multi-stage random sampling method.

At stage 1, the country was divided into five regions: North, Central, Northeast, South, and Bangkok. For each of the North, Central, Northeast and South regions, four provinces were randomly selected (Table 4-2).

Table 4-2 Recruited provinces from four regions

Region	Recruited provinces
North-eastern region	Si Sa Ket; Udon Thani; Maha Sarakham; Nakhon Phanom
Northern region	Lamphun; Chiang Rai; Nakhon Sawan; Phitsanulok
Southern region	Nakhon Si Thammarat; Ranong; Satun; Phattalung
Central region	Ang Thong; Chantha Buri; Kanchanaburi; Samut Sakhon

For Bangkok, four sub-districts were selected by random sampling technique (Table 4-3).

Table 4-3 Recruited districts from Bangkok region

Region	Recruited districts
Bangkok	Lam Phak Chi, Nong Chok district Anusawari, Bang Khen district Khlong Tan Nuea, Watthana district Bang Phai, Bang Khae district

At stage 2, each province was stratified into urban and rural areas. The proportion of the population living in urban versus rural areas is 1:2. Therefore, for each province sample populations were recruited from three survey sites (one urban and two rural areas) in order to reflect the actual proportion of the urban and rural population in that province (Dental Health Division, 2013b).

4.2.3 Data collection

The survey consisted of two main parts. The first part was a clinical examination, based on WHO Oral Health Surveys - basic method 4th edition (World Health Organization, 1997). During the clinical examination, the following data were collected: DMFT, dentition status, root caries, periodontal status, denture status and treatment need for dental caries. The second part was a structured interview. During interviews, personal information, data on oral health behaviours and dental attendance patterns were collected.

4.3 Study population

Only adults who were either between 35-44 or 60-74 years old were selected for this study because individual socio-economic measures were collected only in these age groups.

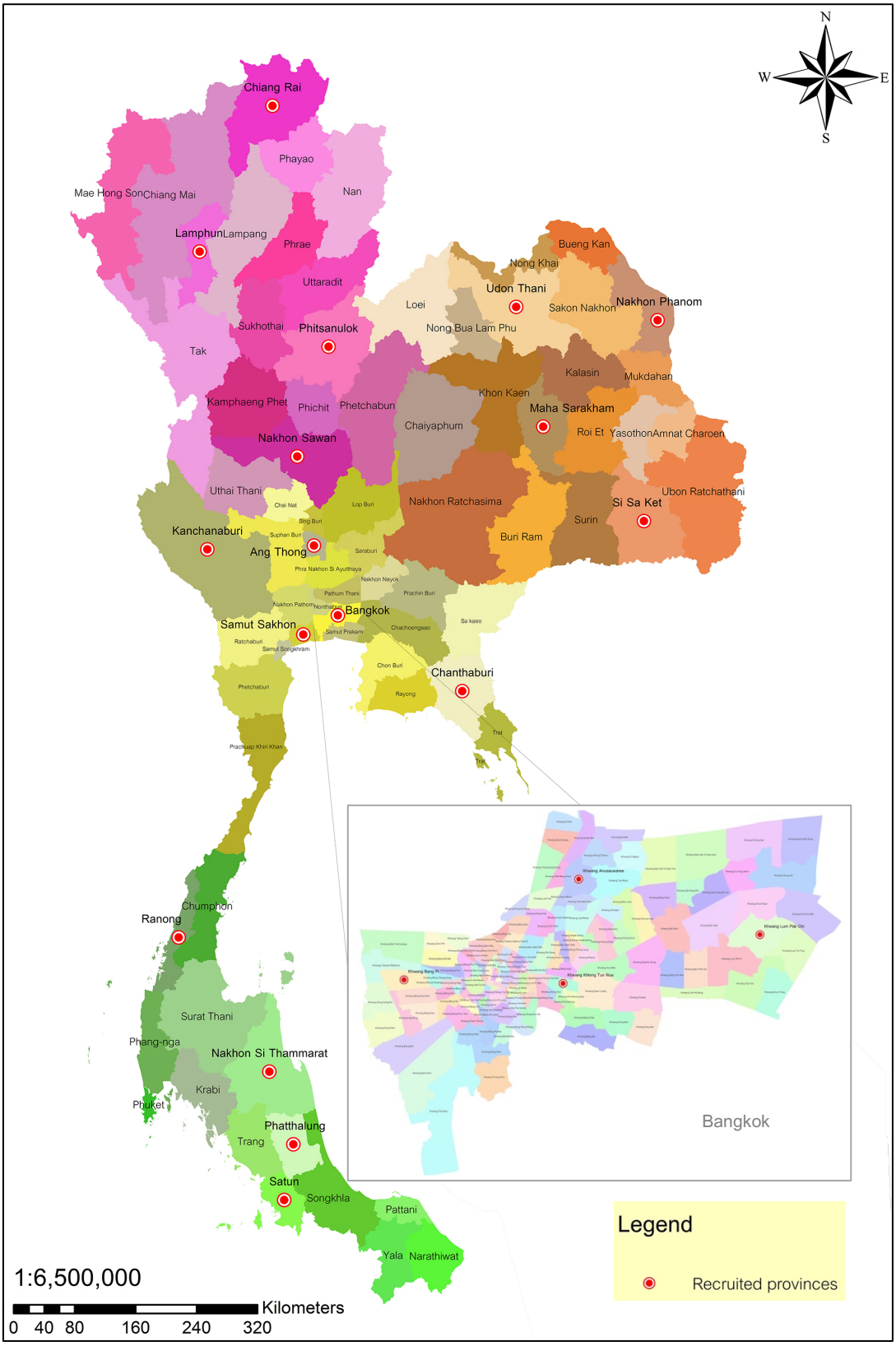

Figure 4-1 Map of Thailand showing 17 provinces, recruited in the 7th Thai National Oral Health Survey

4.4 Variables

As oral health inequalities depend on the choice of oral health outcomes and socio-economic measures (Steele et al., 2015), this study used a range of different variables to capture oral health status and socio-economic position.

4.4.1 Oral health outcomes

Oral examinations were conducted by dentists cooperating with recorders. Participants lay on the table or mobile unit and the examinations were conducted under natural light. Duplicate examinations were performed for approximately ten percent of the total sample population in order to estimate inter- and intra-examiner reproducibility of recordings.

Three oral health measures were used in this study: dental caries, periodontal status, and tooth loss.

Dental caries experience

Dental caries experience (DMFT) and its components (DT, MT, and FT) were used to indicate experience of dental caries. DMFT represents how many teeth have been affected by dental caries.(World Health Organization, 2013).

DT= number of decayed teeth.

MT= number of missing teeth due to dental caries.

FT= number of filled teeth.

DMFT= number of decayed, missing and filled teeth.

Dental caries was recorded when distinctive cavity, undermined enamel presented and also included tooth with temporary filling or permanent filling with carious lesion. Filled teeth were recorded when a permanent restoration, including full crown, was present without a carious lesion.

The DMFT score is widely used in oral health inequalities studies (Schwendicke et al., 2015). For respondents aged 35-44 years, DMFT, number of decayed teeth and number of filled teeth were used in the analysis. For those aged 60-74 years, the number of missing teeth was very high and the cause of tooth loss is difficult to ascertain (Steele et al., 2015). Therefore, only DT and FT were used for the 60-74 age group.

The number of decayed, missing and filled teeth (DMFT), the number of decayed teeth and the number of filled teeth were used in all analyses as a count variable.

Periodontal status

The Community Periodontal Index (CPI) measures periodontal health status, including three indicators; gingival bleeding, calculus and periodontal pockets. Only sextants with at least two teeth remaining were examined and the CPI scores were collected from the following six index teeth:

17 / 16	11	26 / 27
47 / 46	31	36 / 37

If none of the index teeth was present, all remaining teeth in that sextant were examined. Then the highest CPI score was recorded.

Seven codes were used to record periodontal status in the Thai National Oral Health Survey (Dental Health Division, 2009).

0 = Healthy periodontium

1 = Bleeding after probing

2 = Calculus detected

5 = Calculus detected and bleeding after probing

3 = Periodontal pocket 4-5 mm.

4 = Periodontal pocket ≥ 6 mm.

9 = Cannot examine/ Not recorded

A dichotomous variable for periodontal health status was used in the analysis. The highest condition score among six index teeth was selected and dichotomized into two categories:

Code “0” = no deep pocket

Code “1” = presence of deep periodontal pocket ≥ 6 mm. (CPI score=4).

Tooth loss

Tooth loss was measured using two variables: having a non-functional dentition and being edentulous. Firstly, non-functional dentition was defined as having less than 20 natural teeth remaining (World Health Organization, 2013). Secondly, edentulousness indicates complete tooth loss.

Non-functional dentition

A functional dentition (20 or more remaining teeth) refers to a minimum number of natural teeth that should provide adequate masticatory ability and no prosthetic need. On the other hand, having fewer than 20 remaining natural teeth may lead to chewing

problems and inadequate nutrition intake (Ervin and Dye, 2009; Moynihan and Bradbury, 2001; Naka et al., 2014; Sheiham et al., 1999). The number of remaining teeth was obtained from dentition status. A dichotomous variable was created:

Code “0” = having 20 or more remaining teeth

Code “1” = having fewer than 20 remaining teeth

Edentulousness

Edentulousness refers to the condition of losing all teeth. This variable was only used for age group 60-74 (as none of the respondents aged 35-44 had complete tooth loss). A dichotomous variable was created:

Code “0” = having at least one natural tooth remaining

Code “1” = edentulousness.

4.4.2 Socio-economic measures

To assess socio-economic gradient in oral health, both individual and area-level socio-economic measures were used in the analyses.

4.4.2.1 Individual-level socio-economic position

Three individual level socio-economic indicators were available in the dataset: highest educational qualification, personal monthly income, and occupation.

Highest educational qualification

Education is a key marker of socio-economic position. It is easy to measure in self-completed questionnaires and tends to achieve a high response rate (Galobardes et al., 2006b).

Participants were asked about their highest educational qualification. Possible answer options were eight hierarchical levels of education:

- None
- Primary school
- Junior high school
- Senior high school or vocational certificate
- High vocational certificate or diploma
- Bachelor's degree
- Master's degree
- Doctoral degree

The eight categories were collapsed into three categories. Due to the small number of observations in some categories, different categories were derived for different age groups.

Education level for age group 35-44 years:

- Primary school or lower
- High school/ vocational certificate
- High vocational certificate and Bachelor's degree or higher

Education level for age group 60-74 years:

- No education
- Primary school
- High school or higher

Personal monthly income

Participants were asked about their own average monthly income. Six answers were possible, including:

- None
- 1-5,000 THB (~0.02-100 GBP; 1 GBP[1] = 50 THB[2])
- 5,001-15,000 THB (~100-300 GBP)
- 15,001-30,000 THB (~300-600 GBP)
- 30,001-50,000 THB (~600-1,000 GBP)
- ≥50,001 THB (~≥1000 GBP)

Due to the small number of observations in the first and last two categories, three categories were derived:

Code “0” = up to 5,000 THB (≤100 GBP)

Code “1” = 5,001-15,000 THB (~100-300 GBP)

Code “2” = >15,000 THB (>300 GBP)

[1] GBP = Great British Pound
[2] THB = Thai BAHT

Occupation

Participants were asked about their occupation, with twelve answer categories available:

- Employer
- Own business (no own employee)
- Home business (help parent's business and did not receive a salary)
- Government officer
- Employee
- Agriculture
- Work for an association such as Farm women group association or Army wives association etc.
- Unemployed (Housewife)
- Unemployed (Student)
- Unemployed (Elderly)
- Unemployed (Disability)
- Unemployed (Looking for a job)

Unfortunately, there is no clear hierarchy among these categories. Therefore, the occupational variable was not used in the analysis.

4.4.2.2 Area-level socio-economic position

Geographically, Thailand is divided into four regions; Central, South, North and Northeast, covering 77 provinces (76 provinces before 2011) which include Bangkok metropolis. Thai National Oral Health Surveys excluded Bangkok metropolis from the Central region and used Bangkok as another region. Therefore, from the multi-stage sampling method, which has been described in section 4.2.2, the data used in the

analyses had a hierarchical structure with individuals nested in 17 provinces, and provinces nested in five regions. Therefore, two contextual levels were used in the study: regional and provincial levels. The regional level measure was used only for descriptive purposes.

The information at area-level did not come with the National Thai Oral Health survey so the following information was retrieved from different official sources.

Poverty Headcount Ratio

The Poverty Headcount Ratio was used as a socio-economic measure at regional and provincial level. The Poverty Headcount Ratio is calculated by the proportion of the population for whom consumption (or other measures of the living standard) is less than the poverty line. The higher the ratio the greater the proportion of people living below the poverty line.

The poverty line is conceptualized as a minimum standard required by an individual to fulfil their basic food and non-food needs and is expressed in Thai baht/person/month. The poverty line is calculated from minimum food demand (calculated from minimum energy requirement), which depends on age and sex, and minimum non-food demand, which is essential for living. Prices of food and non-food products are based on price in each region/ province. The poverty line will reflect the minimum standard of living of Thai population.

The Thai National Statistical Office reports the Poverty Headcount Ratio for each region and province every year. Information from the year 2012, which were the same year as the surveys, was used in the study.

Regional level

Table 4-4 shows that the regional Poverty Headcount Ratio ranged from 1.91-19.79 and was highest in the North–eastern region (making it the poorest), followed by the North, South, and Central region, and was lowest in Bangkok (Statistical Forecasting Bureau, 2016). To assess the regional gradient in oral health, in the descriptive analyses, region was used as an ordinal variable, ordered by the Poverty Headcount Ratio, from lowest to highest.

Table 4-4 Poverty Headcount Ratio by regions and provinces

Region/Province	Poverty Headcount Ratio
Bangkok	1.91
Central	6.94
Ang Thong	9.59
Chantha Buri	13.89
Kanchanaburi	17.82
Samut Sakhon	5.99
Southern	13.32
Nakhon Si Thammarat	10.87
Phattalung	17.96
Ranong	19.66
Satun	3.26
Northern	17.40
Chiang Rai	24.58
Lamphun	6.77
Nakhon Sawan	17.34
Phitsanulok	10.77
North-eastern	19.79
Maha Sarakham	20.32
Nakhon Phanom	35.28
Si Sa Ket	36.07
Udon Thani	9.96

Provincial level

The Poverty Headcount Ratio by province is the proportion of the poor in that province. Provincial Poverty Headcount Ratio was use as both categorical and continuous variables. For bivariate analyses (in Chapter 5), Provincial Poverty Headcount Ratio, which ranged from 1.91 to 36.07 (Table 4-4), was categorized into the tertiles; high poverty, moderate poverty and low poverty (Table 4-5).

Table 4-5 Provincial Poverty Headcount Ratio tertile in age group 35-44 and 60-74 years

Tertile	Range		
	35-44 years	60-74 years	
1st	1.91-9.96	1.91-9.96	Low poverty
2nd	10.77-19.66	10.77-17.96	Moderate poverty
3rd	20.32-36.07	19.66-36.07	High poverty

For multilevel regression analyses (in Chapter 7), Provincial Poverty Head Count Ratio was used as a continuous variable.

4.4.3 Covariates

4.4.3.1 Individual-level

Demographic status

Oral health and socio-economic position vary by age and sex. Age and sex were therefore used as covariates in all statistical models.

Age

Age was use as both categorical and continuous variables. For descriptive analyses, age was categorized into five-year age bands. Age group 35-44 had two categories (35-39, 40-44 years old) and age group 60-74 had three categories (60-64, 65-69, 70-74 years old). For regression analyses, age in years was used as a continuous variable.

Sex

Sex was used as a covariate in all statistical models. A dichotomous variable was created; 0=male and 1=female.

Oral health-related behaviours

Frequency of tooth brushing

Participants were asked whether they brush their teeth during these following times: morning, after breakfast, after lunch and evening. There is a recommendation of brushing at least twice daily with a fluoride toothpaste in order to prevent dental caries and periodontal diseases (Department of Health, 2017). The total number of tooth brushing was calculated then dichotomous variable was conducted;

Code “0” = tooth brushing <2 times a day

Code “1” = tooth brushing ≥2 times a day

Fluoride toothpaste usage

Participants were asked to name the toothpaste brand they use. Answers were categorized into two categories:

Code “0” = using non-fluoride toothpaste

Code “1” = using fluoride toothpaste.

Past year dental visit

Participants were asked whether they had a dental visit during the past year. Additionally, participants were also asked how many times they visited the dentist during the past year. A variable with three categories was derived.

Code “0” = No dental visit during the past year

Code “1” = One dental visit during the past year

Code “2” = More than one dental visit during the past year

Smoking status

Participants were asked about their smoking status. Answers were divided into three categories:

Code “0” = Non-smoker

Code “1” = Ex-smoker

Code “2” = Current smoker

The effects of smoking on periodontal health are well documented (Tomar and Asma, 2000). Thus, the smoking status variable was used as a covariate in the analyses of deep periodontal pocket and tooth loss.

4.4.3.2 Area-level factors

Three provincial characteristic, including dentist per population ratio, Human Achievement Index (HAI) and GINI index, were used as a covariate at area-level. Table 4-6 shows 17 provinces that were recruited in this study and a summary of provincial characteristics.

Table 4-6 Provincial characteristics

Region/Province	Dentist: population	Dentists: 100,000 population	HAI (2014)	GINI % (2009)
Bangkok	1:6,477	15.4	0.6974	37.6
Central				
Ang Thong	1:10,922	9.2	0.6215	42.3
Chantha Buri	1:12,365	8.1	0.6408	37.5
Kanchanaburi	1:11,181	8.9	0.5891	35.5
Samut Sakhon	1:8,689	11.5	0.6225	36.7
Southern				
Nakhon Si Thammarat	1:15,778	6.3	0.6070	58.0
Phattalung	1:9,157	10.9	0.6471	46.1
Ranong	1:10,180	9.8	0.6556	38.4
Satun	1:10,122	9.9	0.6082	41.1
Northern				
Chiang Rai	1:13,038	7.7	0.6130	48.0
Lamphun	1:9,861	10.1	0.6497	44.7
Nakhon Sawan	1:14,896	6.7	0.6160	44.6
Phitsanulok	1:10,529	9.5	0.6171	50.4
North-eastern				
Maha Sarakham	1:16,534	6.1	0.6320	47.3
Nakhon Phanom	1:23,552	4.3	0.5784	48.4
Si Sa Ket	1:21,091	4.7	0.5714	43.2
Udon Thani	1:17,446	5.7	0.6209	51.9

Dentist per population ratio

The Bureau of Policy and Strategy, Ministry of Health reports the Dentist per population ratio by province, which indicated the size of the population served by one dentist, for every year. Information from the year 2012 was used in the study (as shown in Table 4-6). For bivariate analyses, Dentist per population ratio was categorised into tertile (Table 4-7):

Table 4-7 Dentist per population ratio tertile in age group 35-44 and 60-74 years

Tertile	Range		
	35-44 years	60-74 years	
1st	1:6,477 - 1:10,529	1:6,477 - 1:10,180	High number of dentists
2nd	1:10,922 - 1:16,534	1:10,529 - 1:14,896	Moderate number of dentists
3rd	1:17,446 - 1:23,552	1:15,778 - 1:23,552	Low number of dentists

In addition, the dentist per population ratio was recalculated into the number of dentists per 100,000 population for use as a continuous variable in the multilevel regression models.

Human Achievement Index (HAI)

The Human Achievement Index (HAI) is a composite index, which was developed from the Human Development Index (HDI), used to compare human development between provinces in Thailand. It was first introduced by the United Nations Development Programme (UNDP) Thailand in 2003. The fourth report, which was conducted in 2014, was used in this study (United Nations Development Programme, 2014). The HAI comprises eight indices, which are based on 40 indicators. The eight indices consist of health, education, employment, income, housing and living environment, family and community life, transport and communication, and participation.

For each province, the score for each indicator is calculated by the following calculation.

$$\frac{Actual\ value - Minimum\ value}{Maximum\ value - Minimum\ value}$$

The minimum and maximum values are set at 25% lower and higher than actual minimum and maximum values in order to cover the future value which might be lower or higher than the present value. Some indicators, for example, unemployment and occupational injuries, are negative so the inverse scores (1-calculated value) are used to indicate the development.

A higher HAI score means more advanced human development in that province (as shown in Table 4-6). For bivariate analysis, HAI scores were categorized into tertiles (Table4.8):

Table 4-8 Human Achievement Index tertile in age group 35-44 and 60-74 years

Tertile	Range		
	35-44 years	60-74 years	
1st	0.5714 - 0.6130	Same as	Low HAI score
2nd	0.6160 - 0.6320	age group 35-44 years	Moderate HAI score
3rd	0.6408 - 0.6974		High HAI score

For multilevel regression models, the HAI score was used as a continuous variable. One unit of HAI in the analyses equalled to 0.01 score.

GINI coefficient

The GINI coefficient or GINI index is an indicator for inequality of income distribution. GINI index measures the area between the Lorenz curve and the line of perfect equality. This indicator expresses the percentage of maximum area under the graph, it ranges between zero, which means perfect equality, to 100%, which means perfect inequality (Organisation for Economic Co-operation Development, 2008).

As for the previous provincial characteristics, the GINI index, which ranged from 35.5% to 42.3% (Table 4-6), was categorized into tertiles for the bivariate analyses (Table 4-9):

Table 4-9 Gini Index tertile in age group 35-44 and 60-74 years

Tertile	Range		
	35-44 years	60-74 years	
1st	35.5%-42.3%	35.5%-41.1%	Low GINI index (low inequality)
2nd	43.2%-47.3%	42.3%-47.3%	Moderate GINI Index
3rd	48.0%-58.0%	48.0%-58.0%	High GINI Index (high inequality)

The GINI Index for each province was shown in Table 4-6 and used as a continuous variable in the multilevel model. One unit of GINI Index equalled to 1.0%.

Urban/Rural classification

Many studies among Thai population reported health status between urban and rural areas. In addition, Bangkok is the capital city of Thailand which is locally governed by

Bangkok Metropolitan Administration and had its own health department and health promoting programmes, therefore it was categorized into separate category. This variable consisted of three categories:

Code “0” = Rural area

Code “1” = Urban area

Code “2” = Bangkok area

4.5 Statistical analyses

4.5.1 Descriptive analyses

The characteristics of the sample population such as age, sex, individual-level socio-economic position, oral health behaviour and oral health status were reported. The distribution of all oral health outcomes were explored via cross-tabulations by individual- and area-level socio-economic position. The dental caries status were presented by mean with standard deviation of DMFT, number of decayed teeth and number of filled teeth. The prevalence of periodontal disease (having deep periodontal pocket) and non-functional dentition (having less than 20 natural teeth) were presented by percentage with confidence interval. Survey weight was applied for all analyses. Different survey weights were available for separate age groups, including age group 35-44 add 60-74 years. Therefore, separate analyses were conducted for each age group.

Bivariate analysis was done to assess the association between oral health status, oral health-related behaviours, and each explanatory variable, including both individual- and area-level factors, without any adjustment. Considering DMFT, the number of decayed teeth and the number of filled teeth which were count variables and not normally distributed, the Kruskal-Wallis test was used. For all other oral health outcome and oral health related variables, which were categorical variables, Chi-square test and Chi-square test for trend were used.

The results from all bivariate analyses are presented in tables. In addition, the distributions of oral health measures and oral health-related behaviours by socio-economic measures are also presented via bar graphs.

4.5.2 Regression analyses

Regression modelling was used to explore the associations between oral health outcomes and socio-economic position, to assess social gradients in oral health. This thesis used two types of outcome variables: binary and count outcomes.

4.5.2.1 Regression models for binary outcomes

The logistic regression model was used for binary oral health outcomes, which referred to having deep periodontal pocket, having less than 20 teeth remaining and being edentate.

4.5.2.2 Regression models for count variables

The DMFT, decayed teeth and filled teeth are count variables. Mean, variance, and prevalence of 'zero' scores in the analytical sample of each outcome were calculated and shown in Table 4-10 and Table 4-11. For all variables, the variance was higher than its mean. These implied that all three variables were over-dispersed.

Both Poisson and negative binomial regression are models for count outcomes. Negative binomial regression is used when the outcome is over dispersed. Zero-inflated Poisson (ZIP) and zero-inflated negative binomial (ZINB) regression can be indicated when there is a high frequency of 'zeros' (Long and Freese, 2001; Petrie and Sabin, 2009).

Table 4-10 Distribution of DMFT, the number of decayed teeth, and the number of filled teeth by education and income among 35-44-year-old adults

	DMFT		Decayed teeth		Filled teeth	
	Mean (variance)	% zero	Mean (variance)	% zero	Mean (variance)	% zero
All	5.70 (26.34)	13.32	0.82 (2.92)	64.80	1.46 (7.83)	63.09
Education						
Up to primary school	5.04 (27.66)	17.62	1.03 (4.15)	60.60	0.71 (3.09)	76.50
High school	5.74 (25.73)	11.28	0.72 (2.02)	65.81	1.61 (8.71)	59.32
Bachelor/ higher	7.56 (28.38)	5.56	0.45 (1.25)	74.79	3.32 (14.70)	32.48
Income						
≤5000	4.78 (24.67)	18.20	0.89 (3.59)	65.29	0.92 (5.00)	74.30
5001-15000	5.96 (27.19)	11.29	0.86 (2.89)	62.20	1.42 (7.51)	62.34
>15000	6.79 (24.55)	7.27	0.60 (1.66)	70.55	2.62 (12.34)	43.27

Table 4-11 Distribution of the number of decayed teeth and filled teeth by education and income among 60-74-year-old adults

	Decayed teeth		Filled teeth	
	Mean (variance)	% zero	Mean (variance)	% zero
All	1.63 (6.48)	47.68	0.56 (3.63)	84.69
Education				
No education	2.43 (11.13)	34.83	0.04 (0.11)	97.75
Primary school	1.63 (6.18)	47.34	0.34 (1.52)	87.80
High school/ higher	1.16 (5.09)	57.24	2.21 (15.11)	58.55
Income				
≤5000	1.67 (6.44)	46.42	0.42 (2.34)	87.30
5001-15000	1.67 (7.48)	48.00	0.50 (2.04)	82.80
>15000	1.19 (4.16)	57.14	1.92 (16.32)	68.37

To select the most appropriate statistical model, the 'prcounts' command in STATA® was used. The 'prcounts' is a post-estimation command, used to generate predicted probabilities. It creates three new variables: the predicted rate, the probability of each count and the cumulative probabilities. Then, the difference between the observed and predicted probabilities can be computed and plotted (Long and Freese, 2001).

Figure 4-2 and Figure 4-3 show the differences between predicted and observed rates of each count from different models. The best-fitting model is the one where the predicted rate is very close to the observed rate (the difference is close to zero).

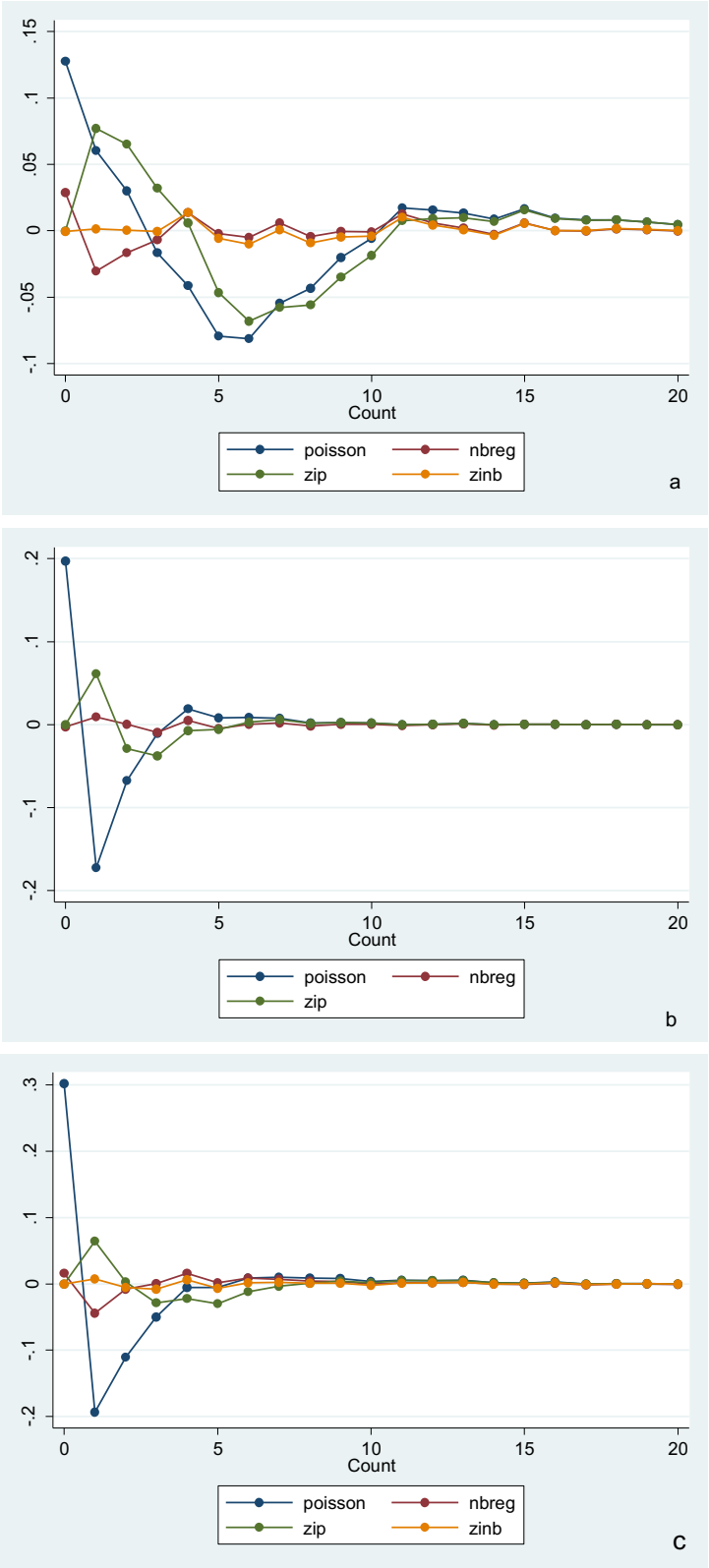

Figure 4-2 the differences between the observed proportions for each count and the mean probability from the four models (a) DMFT (b) decayed teeth (c) filled teeth among 35-44-year-old adults

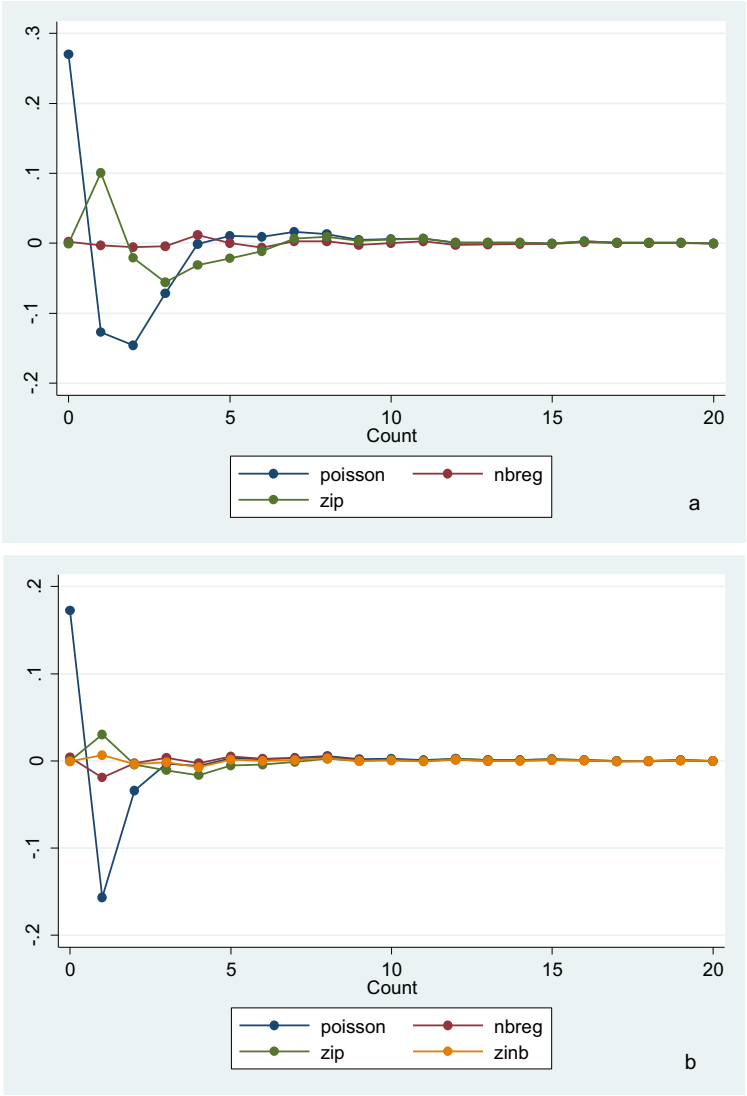

Figure 4-3 the differences between the observed proportions for each count and the mean probability from the four models (a) decayed teeth (b) filled teeth among 60-74-year-old adults

Figure 4-2 (a) shows that the best-fitted model for DMFT was the zero-inflated negative binomial model (ZINB). ZINB model predicted zero to three counts better than negative binomial model. Negative binomial and ZINB were similar for predicting four and onward counts. However, when analysing the association between DMFT and education using ZINB, the results showed very wide confident intervals, which could be the result of a low frequency of 'zero' counts (Table 4-10). Therefore, the negative binomial model was used when DMFT was an outcome in the analyses.

Figure 4-2 (b) and Figure 4-3 (a) show that the best-fitting model for the number of decayed teeth was the negative binomial model. The graphs showed no predicted line for the ZINB model due to convergence problems. Figure 4-2 (c) and Figure 4-3 (b) show that the best-fitting model for the number of filled teeth was the ZINB model. ZINB was slightly better in predicting zero and one counts among 35-44-year-old adults and predicting one count among 60-74-year-old adults compared to the rest models.

In brief, negative binomial models were used for DMFT and decayed teeth and zero-inflated model were used for filled teeth in both age groups

Negative binomial model

As mentioned earlier, negative binomial models are used when the outcome is an over-dispersed count variable. Similar to the logistic regression model, which uses logit transformation of probability, the negative binomial regression uses the natural log transformation of the mean or rate to solve the mathematical problem. (Petrie and Sabin, 2009; Zwilling, 2013).

$$Rate = \frac{number\ of\ events\ occurring}{Total\ number\ of\ years\ of\ follow-up\ for\ all\ individual}$$

$$\ln(\mu) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k$$

where: μ = estimated value of the mean or expected rate

β_0(constant) = estimate of the log rate when all explanatory variables are zero

$\beta_1, \beta_2, \ldots, \beta_k$ = estimated negative binomial regression coefficient

The exponential of the negative binomial coefficient becomes an Incident Rate Ratio (Relative Rate). If the Incident Rate Ratio is equal to one, it means that that the event rate is the same when value of explanatory variable increases one unit or when compared with the reference group.

Zero-inflated negative binomial model

Zero-inflated negative binomial regression has been increasingly used for dental caries research, as it allows to model excessive zero counts (Preisser et al., 2016; Preisser et al., 2012).

Zero-inflated negative binomial regression consists of two parts, based on the theory suggested that the excessive zero counts and the number of event are caused by two different processes. For example, an individual may or may not have dental caries. If the individual does not have dental carries, the only outcome possible is zero. If the individual had dental caries, the extent of caries can be counted and could be low or high. Therefore, the two parts of the zero-inflated negative binomial model are a logit model, to model the probability of having zero counts of dental caries, and a negative binomial model, to model the count process (UCLA: Statistical Consulting Group, 2011).

The interpretation of the zero-inflated model is also divided into two parts. The interpretation of the logit part is similar to a logistic regression model and the negative binomial part is interpreted similar to a negative binomial regression model as described earlier.

4.5.2.3 Assessing the social gradient in oral health status: single-level models

Education and income gradients in the oral health outcomes were assessed separately. For each oral health outcome, the following four models were run:

Model 1: The association between oral health outcome and education

Model 2: Model 1 and additionally adjusted for age and sex

Model 3: The association between oral health outcome and income

Model 4: Model 3 and additionally adjusted for age and sex

4.5.3 Multilevel models

Multilevel models are used to model cluster or hierarchical data; individuals are nested in higher-level units, for example, geographical areas or institutions. Individuals from the same cluster are more likely to be similar by sharing the same characteristics / environment. Ignoring the cluster may cause underestimation of standard errors from the regression. Multilevel models allow the variation between clusters, therefore benefit by estimating correct standard errors.

In this study, multilevel models were used to assess how oral health outcomes varied across provinces, and whether these outcomes were influenced by factors operating at provincial-level.

4.5.3.1 Multilevel data structure

Data from Thai National Oral Health surveys have a three-level structure, with participants nested in provinces and provinces nested in regions (Figure 4-4). Because the number of regions was very small (five), the multilevel analyses in this study used only two-level models with provinces as the higher level.

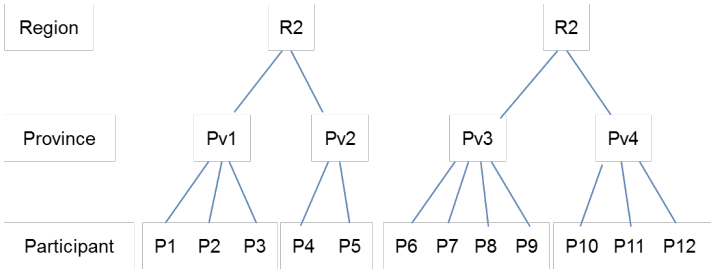

Figure 4-4 Diagram of a three-level nested structure; individuals in provinces in regions

4.5.3.2 Multilevel linear regression

The multilevel linear regression is applied for continuous outcomes. The following equation shows a two-level random intercept model predicting outcome y of individual i in the province j. The equation is similar to the single-level linear regression model but the two-level random intercept model allows the intercept to vary across different provinces. The intercept for province j equals to β_0+u_j.

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + u_j + e_{ij}$$

y_{ij} = outcome y of individual i in the province j

β_0= overall constant / intercept

β_1= overall slope/ relationship between outcome and explanatory variable x

u_j= provincial-level residuals, which is the difference between the mean of province j and overall mean of y

e_{ij}= individual-level residual for individual i in a province j

The residual for both individual- and provincial-level are expected to follow the normal distribution, where the mean equals to zero and the variance equals to σ^2.

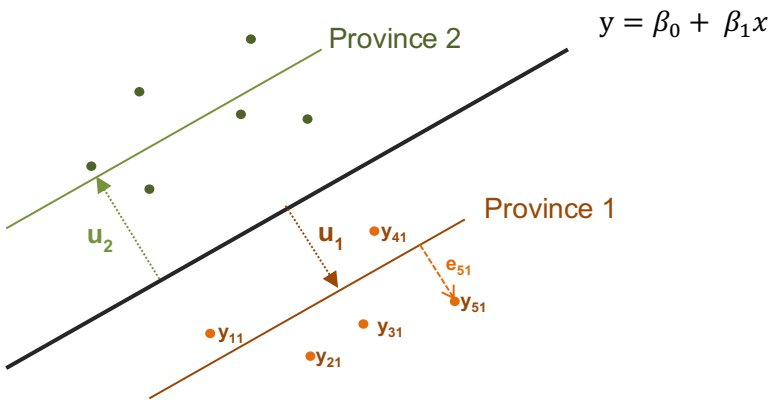

Figure 4-5 Random intercept model showing individual- and provincial- level residuals

4.5.3.3 Multilevel logistic regression

Similar to single level logistic regression, logistic transformation of the probability of having a condition was used in the fitted model in order to achieve the mathematical problem of a binary outcome. The following equation is the two-level random intercept model.

$$\log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_{0j} + \beta_1 x_{ij} + u_j$$

π_{ij} = probability of having a condition/disease of individual i in a province j

β_0= overall constant / intercept

β_1= overall slope/ relationship between outcome and explanatory variable x

u_j= provincial-level residuals, which is the difference between the mean of province j and overall mean of y

The individual-level residuals in the multilevel logistic regression model are assumed to follow the logistic distribution, which means that the mean equals to zero and the variance equals to $\frac{\pi^2}{3}$=3.29. The provincial-level residuals in the multilevel logistic

regression are still expected to follow the normal distribution, where the mean equals to zero and the variance equals to σ_u^2.

Interpretation of the multilevel logistic regression

The between-province variance (level-two variance, σ_u^2) indicates the differences between provinces. If the p-value of σ_u^2 is less than 0.05, there is a significant difference between provinces. It also can be interpreted as a variance partition coefficient (VPC), which indicates the proportion of the total variance that is due to differences between provinces.

$$VPC = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_e^2}$$

σ_u^2= between-province variance

σ_e^2=individual-level variance, as mentioned before, individual-level variance for logistic distribution equals to $\frac{\pi^2}{3}$=3.29.

The exponential of β_0 is the odds of having a condition (y=1) when x=0 and u=0, which is the overall intercept. We can calculate the probability (π) of having a condition for average province (u=0); $\pi = \frac{Odds}{1+Odds} = \frac{\exp \beta_0}{1+exp\beta_0}$

Similar to single level model, the exponential of β_1 can be interpreted as odds ratio.

4.5.3.4 Multilevel negative binomial regression

Similar to single level negative binomial regression, the multilevel negative binomial regression uses the natural log transformation of the mean or rate to obtain the linear model. The following equation is the two-level random intercept negative binomial regression predicting rate for an individual i in a province j.

$$\ln\left(\mu_{ij}\right) = \beta_{0j} + \beta_1 x_{ij} + u_j$$

μ_{ij}= estimate value of the mean /rate for an individual i in a province j

β_0= overall constant / intercept

β_1= overall slope/ relationship between outcome and explanatory variable x

u_j= provincial-level residuals, which is the difference between the mean of province j and overall mean of y

Interpretation of the multilevel negative binomial regression

Similar to multilevel logistic regression, the between-province variance (level-two variance,σ_u^2) indicates the differences between provinces. However, for multilevel negative binomial regression, the VPC cannot be calculated.

The over-dispersion parameter is expected to be higher than zero. It indicates that the data is over-dispersed and fit a binomial distribution.

Similar to single-level model, the exponential of β_1 can be interpreted as the Incident Rate Ratio.

4.5.3.5 Assessing the association between individual-, area-level factors and oral health status using multilevel models

Multilevel negative binomial models were used for the DMFT, number of decayed teeth and number of filled teeth. STATA14 does not have a command for analysing multilevel zero-inflated negative binomial models. Therefore, the number of filled teeth was also analysed using a multilevel negative binomial model.

Multilevel logistic regression was used for all binary outcomes, including having deep periodontal pockets, having less than 20 teeth remaining, and being edentate.

For each oral health outcome, the following series of models were estimated (all models were run separately for each age group):

Model 1 is the null model. Only the outcome was added in the two-level random intercept model in order to assess the variation of the oral health outcome in question between the provinces, without any adjustment.

Model 2 adjusted for education and Model 3 adjusted for income. Adjustments for education and income were done separately to assess the relationship of each explanatory variable with the oral health outcomes after accounting for the variation between provinces.

Model 4 adjusted for both education and income together, in order to examine the relative importance of education and income for oral health inequalities.

Model 5 adjusted additionally for demographic variables (age and sex) and oral health-related behaviours. Age was centred at the mean in order to improve the interpretation of the constant. For oral health-related behaviours, different variables were used for each oral health outcome.

- For dental caries outcomes, use of fluoride toothpaste and the number of dental visits during the past year were added into the model since fluoride plays an important roles in dental caries prevention (Griffin et al., 2007). In addition, more dental visits has been associated with a higher number of filled teeth (Sheiham et al., 1985)

- For having deep periodontal pockets, frequency of tooth brushing and smoking status were added since there is an evidence that irregular tooth brushing and smoking have been associated with periodontal diseases. (Bergström, 2004; Tomar and Asma, 2000; Zimmermann et al., 2015).
- For tooth loss, smoking and the number of dental visits during the past year were added since there is evidence on the association between smoking and dental attendance on tooth loss (Hanioka et al., 2011; Thomson et al., 2010; Tiwari et al., 2016)

These models assessed how much the between-province variation was accounted for by individual-level measures.

Model 6 adjusted additionally for area characteristics. All area-level characteristics, including the Poverty Headcount Ratio, dentists per 100,000 population, Human Achievement Index (HAI) and GINI, were added into the model. All these variables were also centred at their mean in order to improve the interpretation of the constant.

Model 7 was a fully adjusted model, adjusted additionally for urban/rural.

4.6 Sample sizes and missing data

Figure 4-6 shows how the analytical samples for both age groups were derived. For age group 35-44, the baseline sample was 1,518. No participants were excluded due to being edentate. Only one respondent was excluded from the study because of missing information on personal monthly income. Therefore, the analytical sample of 35-44-year-old adults was 1,517.

The baseline sample for participants aged 60-74 was 1,264. Then two sets of analytical samples were created for different outcomes. First, for edentulousness, no respondent was excluded due to missing data, therefore the analytical sample for edentulousness was 1,264. Second, for the analyses of the other oral health variables, 91 (7.21%) edentulous respondents were excluded. Of the remaining participants, 30 had missing data on the use of fluoride toothpaste (2.56%) and were excluded from the study. Finally, the analytical sample was 1,143.

Because of the small number of respondents with missing data, all analyses in this study are based on complete cases.

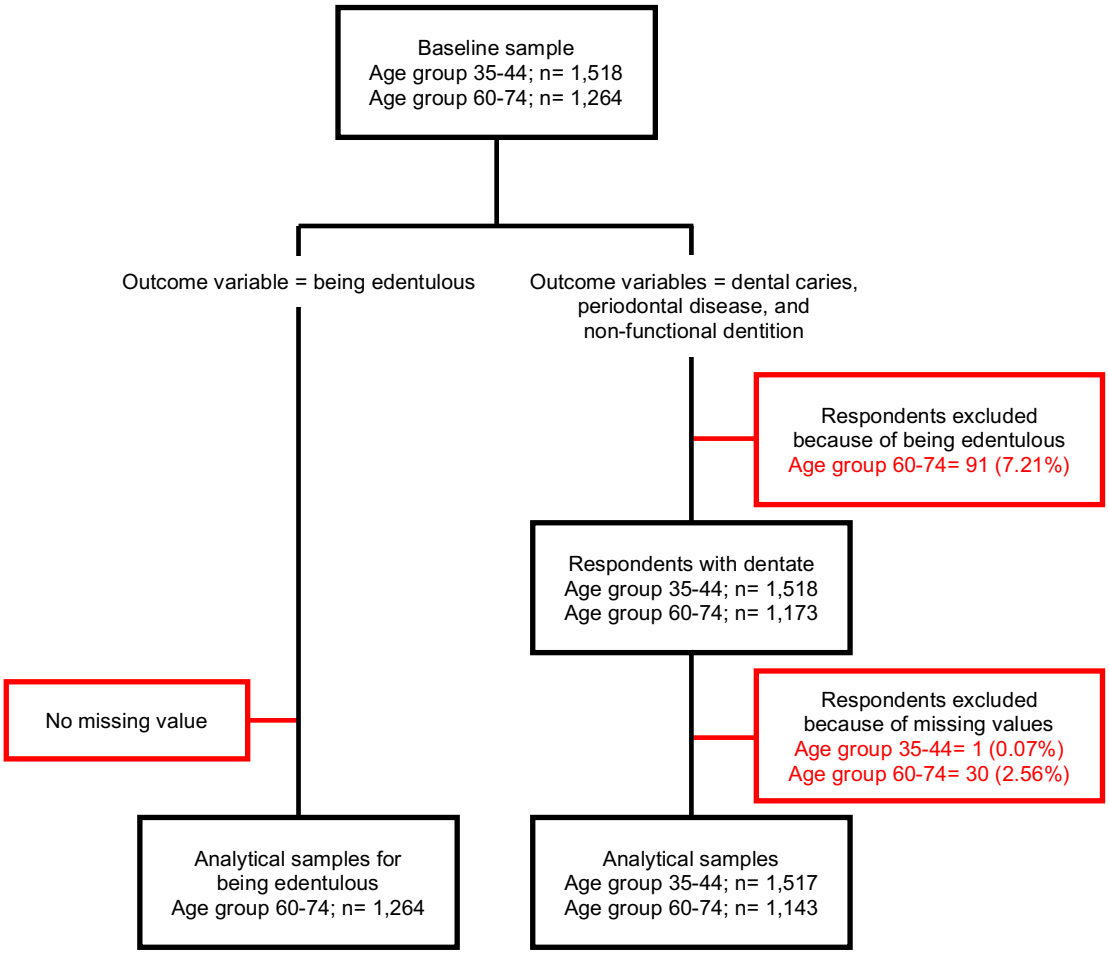

Figure 4-6 Analytical samples and excluded samples aged 35-44 and 60-74 years old

Chapter 5 Descriptive and bivariate analyses

5.1 Introduction

This chapter reported results from descriptive statistics, using the 7th Thai National Oral Health Survey as a data source. First, descriptive statistics were used to explore the sample characteristics and distribution of all variables. Second, bivariate analyses were used to assess the associations between oral health outcomes, oral health-related behaviours, individual-, and area-level characteristics. In addition, this chapter also reported social gradient in oral health outcomes and oral health-related behaviours, based on bivariate analyses without any adjustment. Therefore, this chapter addressed part of objective one and two of the thesis.

5.2 Sample characteristics

Table 5-1 shows characteristics of the sample population, including age group 35-44 and 60-74 years. Weighted percentage and mean were used to report the distribution of sample population.

5.2.1 Age group 35-44 years

Over half of the sample were female (52.8%) and aged 40-44 years (53.0%). Mean age was 39.6 (SD=2.8). Nearly half of 35-44-year-old adults (45.7%) had low education level (finished up to primary school) and 47.3% earned 5,001-15,000 Thai BAHT per month (approximate 100-300 GBP). During the past year, over 60% of the sample did not visit the dentist, 24% visited once, and 15% visited two or more times. Only a quarter of the sample did not use fluoride toothpaste. More than 90% of the sample brushed their teeth at least twice a day. In term of smoking status, 72.6% of the sample aged 35-44 years were a non-smoker, 6.8% were ex-smoker, and 20.6% were a current smoker.

The mean number of DMFT, decayed teeth and filled teeth were 6.0 (SD=5.1), 0.8 (SD=1.6), and 1.6 (SD=2.8) teeth/person respectively. In addition, the prevalence of deep periodontal pocket was 4.6%, and the prevalence of non-functional dentition was 2.6%.

5.2.2 Age group 60-74 years

About a half of the sample were female. More than 40% of the sample were from age group 60-64 years, 37% from age group 65-69 years, and 20% from age group 70-74 years. Mean age was 65.8 (SD=4.0) years. Most of 60-74-year-old adults had middle education level (finished primary school; 77%), followed by high education level (high school/higher; 16%) and no education (7%). The majority of the sample aged 60-74 years, around 70%, had low income, and followed by middle income (25%) and high income (5%). In addition, 70% of older adults did not visit the dentist during the past year and a half of individuals who visited the dentist during the past year had more than one dental visit. The majority of the sample (over 80%) brushed their teeth two or more times a day and only a quarter of the sample did not use fluoride toothpaste. Over 70% of the sample were a non-smoker, followed by current smoker (15%) and ex-smoker (12%).

The mean number of decayed teeth and filled teeth were 1.4 (SD=2.4), 0.5 (SD=1.5) teeth/person respectively. In addition the prevalence of deep periodontal pocket was 11.9%, the prevalence of non-functional dentition and edentulousness was 38.5% and 7.5% respectively.

Table 5-1 Sample characteristics

	Age 35-44 (n=1,517)		Age 60-74 (n=1,143)[a]
Sex (%)			
Male	47.2		50.2
Female	52.8		49.8
Age, mean(SD)	39.6 (2.8)	**Age**, mean(SD)	65.8 (4.0)
35-39	47.0	60-64	42.7
40-44	53.0	65-69	36.6
		70-74	20.7
Education (%)		**Education (%)**	
Up to primary school	45.7	No education	7.1
High school	37.0	Primary school	76.5
Bachelor/higher	17.4	High school/higher	16.4
Personal monthly income (%)			
0-5000 THB	34.0		69.2
5001-15000 THB	47.3		25.1
>15000 THB	18.7		5.7
Number of dental visit during the past year (%)			
None	61.4		69.4
1 time	23.8		15.5
> 1 time	14.8		15.2
Fluoride toothpaste usage (%)			
No	22.7		23.2
Yes	77.3		76.8
Brushing frequency (%)			
< 2 times	7.6		18.5
2 or more times	92.4		81.5
Smoking status (%)			
Non-smoker	72.6		72.7
Ex-smoker	6.8		12.0
Current smoker	20.6		15.3
DMFT, mean(SD)	6.0 (5.1)		-
D-component, mean(SD)	0.8 (1.6)		1.4 (2.4)
F-component, mean(SD)	1.6 (2.8)		0.5 (1.5)
Presence of deep pocket (%)	4.6		11.9
Non-functional dentition (%)	2.6		38.5
Edentulousness (%)[a]	-		7.5

[a] all summary statistics was calculated only for dentate adults (completed case analysis) except prevalence of edentulousness which was calculated from the full sample size of age group 60-74 (n=1,264)

5.3 Associations between oral health outcome and individual-level charateristics

This section will report the results from bivariate analyses, evaluating associations between oral health outcome and individual-level characteristics among 35-44 and 60-74-year-old adult.

Two statistical tests were used to evaluate the association between oral health outcome and individual-level characteristics. First, the Kruskral-Wallis test is the test for the non-normally distributed continuous outcome variable. Kruskral-Wallis test was used for DMFT, the number of decayed teeth and the number of filled teeth outcomes. Second, the Chi-square test and Chi-square test for trend are the test for evaluating the association between two categorical variables, which were having deep periodontal pocket, having less than 20 teeth, being edentulous and all individual-level characteristics.

5.3.1 Dental caries experience

DMFT

The mean number of DMFT was used only for age group 35-44 years. Table 5-2 shows the distribution of DMFT by individual-level factors. The average number of DMFT was higher among age group 40-45 years (6.3 teeth/person SD=5.3) than age group 35-39 years (5.7 teeth/person SD=4.9), but there was no statistically significant difference. Female had significantly higher mean number of DMFT (6.7 teeth/person SD=5.4) compared to male (5.3 teeth/person SD=4.7). Also, individuals who had high socio-economic position were significantly associated with higher number of DMFT. The mean number of DMFT was the highest among people who finished bachelor's degree/higher (8.0 teeth/person SD=4.4), followed by who finished high school (5.7

teeth/person SD=5.0), and who finished up to primary school (5.5 teeth/person SD=5.3). The mean number of DMFT was the highest among individuals whose income >15,000 THB (7.2 teeth/person SD=4.6), followed by whose income 5,001-15,000 THB (6.3 teeth/person SD=5.1), and whose income 0-5,000 THB (5.0 teeth/person SD=5.3). Besides, the number of DMFT was also significantly associated with the number of the dental visit during the past year, used of fluoride toothpaste and smoking status. The mean number of DMFT was higher among participants who had more than one dental visits during the past year (8.3 teeth/person SD=4.8), who were a non-smoker (6.3 teeth/person SD=5.2), and who used a non-fluoride toothpaste (6.2 teeth/person SD=4.9).

Without any adjustment, Figure 5-1 shows reverse education and income gradients in DMFT. The number of DMFT increased at each higher step of socio-economic position.

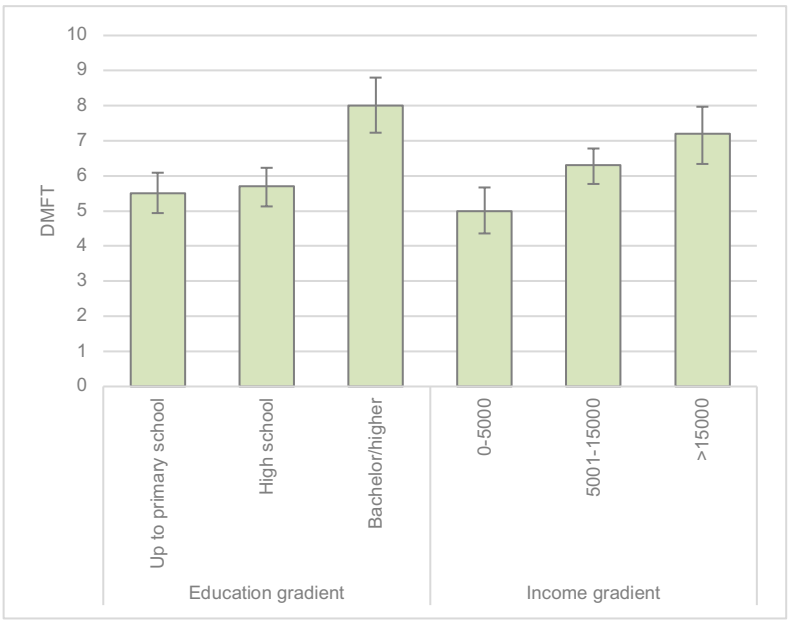

Figure 5-1 Education and income gradient in the mean number of DMFT among 35-44-year-old adults.

Decayed teeth

The mean number of decayed teeth was evaluated among both age group 35-44 and 60-74 years. Among age group 35-44 years, the number of decayed teeth was statistically significant associated with socio-economic position and brushing frequency (Table 5-2). The mean number of decayed teeth was the highest among people who finished up to primary school (1.0 teeth/person SD=2.0), followed by who finished high school (0.7 teeth/person SD=1.3), and who finished bachelor's degree/higher (0.4 teeth/person SD=0.9). The mean number of decayed teeth was the highest among individuals whose income 0-5,000 THB (0.9 teeth/person SD=2.0), followed by whose income 5,001-15,000 THB (0.7 teeth/person SD=1.5), and whose income >15,000 THB (0.5 teeth/person SD=1.0). Brushing frequency was the only oral health-related behaviour that was statistically significant associated with the number of decayed teeth; respondents who brushed their teeth less than twice a day had a significantly higher number of decayed teeth (1.0 teeth/person SD=2.2) compared to those who brushed their teeth at least twice a day (0.7 teeth/person SD=1.6).

Among age group 60-74 years, the mean number of decayed teeth was statistically significant associated with education but was not associated with income group. In addition, none of oral health-related behaviour was significantly associated with the number of decayed teeth (Table 5-3). The mean number of decayed teeth was highest among individuals who had no education (1.9 teeth/person SD=2.9), followed by who finished primary school (1.4 teeth/person SD=2.4), and who finished high school/higher (1.1 teeth/person SD=1.8).

Figure 5-2 shows clear education gradients in the number of decayed teeth among both age groups. The mean number of decayed teeth decreased at each higher level of education. In contrast, the statistically significant income gradient was found only among the age group 35-44 years. The highest mean number of decayed teeth was found among the lowest income group, and then the mean number of decayed teeth was lower at each higher level of income.

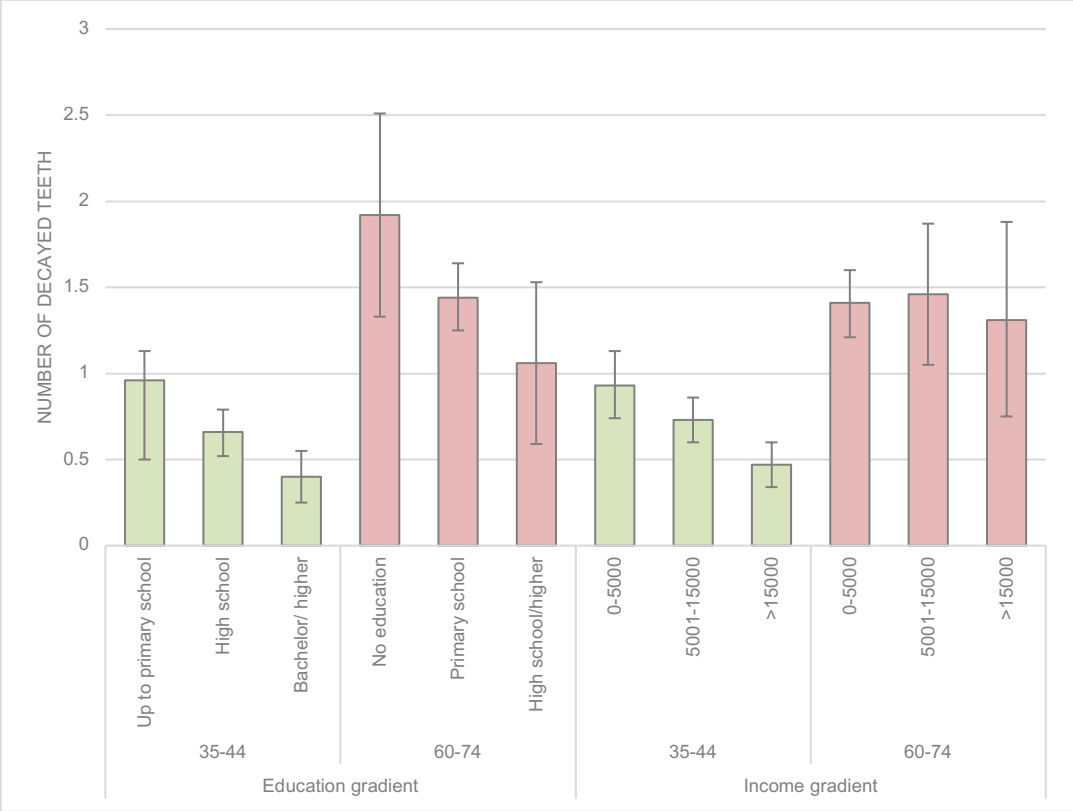

Figure 5-2 Education and income gradient of decayed teeth among 35-44 and 60-74-year-old adults

Filled teeth

Among age group 35-44 years, the number of filled was statistically significantly associated with sex; the mean number of filled teeth was higher among female (1.9 teeth/person SD=2.9) compared to male (1.3 teeth/person SD=2.6). The number of filled teeth was also associated with both education and income. The highest number of filled teeth was found among people who finished bachelor's degree/higher (3.9 teeth/person SD=3.2) and had income >15,000 THB (3.2 teeth/person SD=3.5), followed by who finished high school (1.5 teeth/person SD=2.9) and had income 5,001-15,000 (1.5 teeth/person SD=2.7). The lowest mean number of filled teeth was found among those who had education up to primary school (0.8 teeth/person SD=1.8) and who had income 0-5,000 THB (0.8 teeth/person SD=1.9). In addition, the number of filled teeth was also significantly associated with the number of past year dental visit; the mean number of filled teeth among individuals who had more than one dental visit, who had one visit, and who did not visit the dentist was 3.2 (SD=3.4), 2.3 (SD=3.1), and 0.9 (SD=2.1) teeth/person respectively. Furthermore, the higher number of filled teeth was also associated with being non-smoker (1.8 teeth/person SD=3.0) and brushing twice or more a day (1.6 teeth/person SD=2.8) (Table 5-2).

Among age group 60-74 years, the mean number of filled was significantly associated with sex. Female had a higher mean number of filled teeth (0.6 teeth/person SD=1.7) compared to male (0.4 teeth/person SD=1.3). The number of filled teeth was also significantly associated with education and income. The highest number of filled teeth was found among people who finished high school/higher (1.3 teeth/person SD=2.4) and had income >15,000 THB (1.4 teeth/person SD=4.1), followed by who finished primary school (0.3 teeth/person SD=1.2) and had income 5,001-15,000 (0.5 teeth/person SD=1.1), and the lowest mean number of filled teeth was found among

those who had no education (0.1 teeth/person SD=0.4) and who had income 0-5,000 THB (0.4 teeth/person SD=1.4). Furthermore, the number of filled teeth was also associated with all behavioural variables. The number of filled teeth had positive association with the number of dental visit during the past year. The mean number of filled teeth was lowest among those who did not have dental visit (0.3 teeth/person SD=1.1), followed by who had one dental visit (0.5 teeth/person SD=1.6), and was highest among who had more than one dental visit (1.4 teeth/person SD=2.8). Moreover, the higher mean number of filled teeth was found among individuals who brushed twice or more a day (0.6 teeth/person SD=1.7), did not used fluoride toothpaste (0.5 teeth/person SD=1.8) and were a non-smoker (0.6 teeth/person SD=1.7) (Table 5-3).

Figure 5-3 clearly shows the reverse education and income gradient in a number of filled teeth for both age groups. The mean number of filled teeth increased at each higher level of education and income.

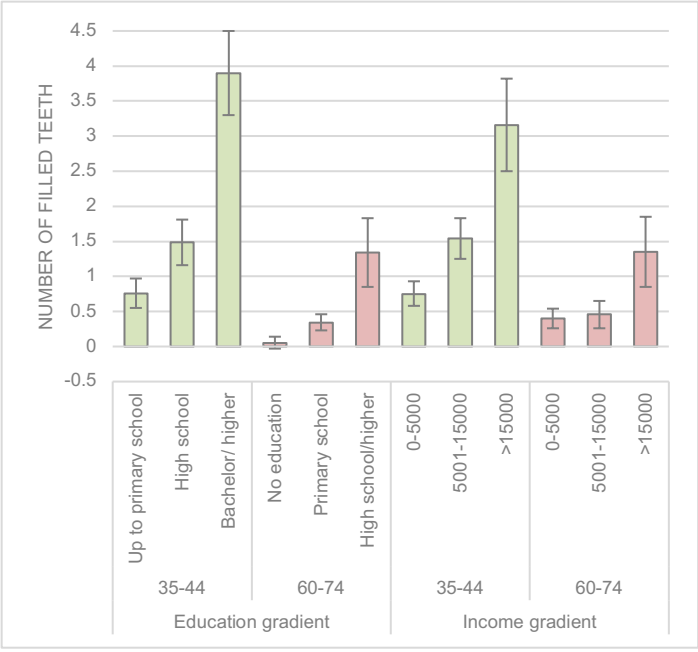

Figure 5-3 Education and income gradient in filled teeth among 35-44 and 60-74-year-old adults

Table 5-2 The associations between dental caries and individual-level characteristics among 35-44-year-old adults (n=1,517)

	DMFT		Decayed teeth		Filled teeth	
	Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Age group						
35-39	5.7 (4.9)	0.2035	0.8 (1.8)	0.2968	1.7 (2.9)	0.0856
40-45	6.3 (5.3)		0.7 (1.4)		1.4 (2.7)	
Sex						
Male	5.3 (4.7)	**<0.001**	0.7 (1.6)	0.2128	1.3 (2.6)	**<0.001**
Female	6.7 (5.4)	***	0.8 (1.6)		1.9 (2.9)	***
Education						
Up to primary	5.5 (5.3)	**<0.001**	1.0 (2.0)	**<0.001**	0.8 (1.8)	**<0.001**
High school	5.7 (5.0)	***	0.7 (1.3)	***	1.5 (2.9)	***
Bachelor/higher	8.0 (4.4)		0.4 (0.9)		3.9 (3.2)	
Income						
0-5000	5.0 (5.3)	**<0.001**	0.9 (2.0)	**0.0427**	0.8 (1.9)	**<0.001**
5001-15000	6.3 (5.1)	***	0.7 (1.5)	*	1.5 (2.7)	***
>15000	7.2 (4.6)		0.5 (1.0)		3.2 (3.5)	
Past year dental visit						
No	5.1 (5.0)	**<0.001**	0.8 (1.7)	0.6034	0.9 (2.1)	**<0.001**
1	7.1 (4.9)	***	0.8 (1.6)		2.3 (3.1)	***
>1	8.3 (4.8)		0.6 (1.3)		3.2 (3.4)	
Used of F toothpaste						
No	6.2 (4.9)	**0.0218**	0.8 (1.6)	0.2234	1.7 (3.1)	0.1267
Yes	6.0 (5.2)	*	0.7 (1.6)		1.5 (2.7)	
Brushing frequency						
<2	5.2 (5.1)	0.3497	1.0 (2.2)	**0.0219**	0.8 (2.1)	**0.003**
2 or more	6.1 (5.1)		0.7 (1.6)	*	1.6 (2.8)	**
Smoking status						
No	6.3 (5.2)	**<0.001**	0.8 (1.7)	0.2474	1.8 (3.0)	**<0.001**
Ex-smoker	4.8 (5.4)	***	0.6 (1.3)		1.0 (2.3)	***
Current smoker	5.3 (4.9)		0.8 (1.4)		0.8 (1.8)	

p-value: ***p<0.001; **p<0.01; *<0.05

Table 5-3 The associations between dental caries and individual-level characteristics among 60-74-year-old adults (n=1,143)

	Decayed teeth		Filled teeth	
	Mean (SD)	p-value	Mean (SD)	p-value
Age group				
60-64	1.3 (2.2)	0.0501	0.5 (1.5)	0.6887
65-69	1.4 (2.4)		0.5 (1.6)	
70-74	1.7 (2.6)		0.4 (1.5)	
Sex				
Male	1.5 (2.3)	0.9088	0.4 (1.3)	**<0.001**
Female	1.3 (2.4)		0.6 (1.7)	***
Education (%)				
No education	1.9 (2.9)	**<0.001**	0.1 (0.4)	**<0.001**
Primary school	1.4 (2.4)	***	0.3 (1.2)	***
High school/higher	1.1 (1.8)		1.3 (2.4)	
Income				
0-5000	1.4 (2.3)	0.0847	0.4 (1.4	**<0.001**
5001-15000	1.5 (2.4)		0.5 (1.1)	***
>15000	1.3 (2.7)		1.5 (4.1)	
Past year dental visit				
No	1.6 (2.5)	0.0714	0.3 (1.1)	**<0.001**
1	1.2 (2.1)		0.5 (1.6)	***
>1	1.0 (1.7)		1.4 (2.8)	
Used of F toothpaste				
No	1.5 (2.8)	0.4837	0.5 (1.8)	**0.0187**
Yes	1.4 (2.2)		0.5 (1.5)	*
Brushing frequency				
<2	1.6 (2.6)	0.5029	0.04 (0.3)	**<0.001**
2 or more	1.4 (2.3)		0.6 (1.7)	***
Smoking status				
No	1.3 (2.2)	0.2406	0.6 (1.7)	**<0.001**
Ex-smoker	2.1 (3.1)		0.2 (0.8)	***
Current smoker	1.3 (2.1)		0.2 (1.1)	

p-value: ***p<0.001; **p<0.01; *<0.05

5.3.2 Periodontal diseases

Having deep periodontal pocket (≥6mm.)

Among adults, aged 35-44 years, having deep periodontal pocket was significantly associated with sex and education (Table 5-4). Male participants were more likely to have a deep periodontal pocket (4.7%; 95%CI 3.3-6.6) compared to female participants (4.4%; 96%CI 2.7-7.3). In addition, the chi-square test for trend showed significant linear trend of the association between deep periodontal pocket and education level (p for trend=0.0101). The highest prevalence of a deep periodontal pocket was found among participants, had education up to primary school (5.8%; 95%CI 4.2-8.0), followed by who finished high school (4.0%; 95%CI 2.0-8.1), and who finished bachelor's degree/higher (2.4%; 95%CI 1.1-5.1).

Among adults, aged 60-74 years, prevalence of having deep periodontal pocket decreased at each older age group (p for trend=0.0308) (Table 5-5); the youngest age group (60-64 years) had the highest prevalence of deep periodontal pocket (13.9%; 95%CI 10.2-18.5). Having deep periodontal pocket was significantly associated with only personal monthly income. The middle-income group had the highest prevalence of deep periodontal pocket (17.0%; 95%CI 11.4-22.7), followed by low-income group (10.8%; 95%CI 8.3-14.0), and the high-income group had the lowest prevalence of deep periodontal pocket (2.0%; 95%CI 0.6-6.8).

Figure 5-4 shows education and income gradient in having deep periodontal pocket among age group 35-44 years, however, only education gradient were statistically significant. Among age group 60-74 years, although, the highest education and income groups had the lowest prevalence of deep periodontal pocket, no education and income gradient were found.

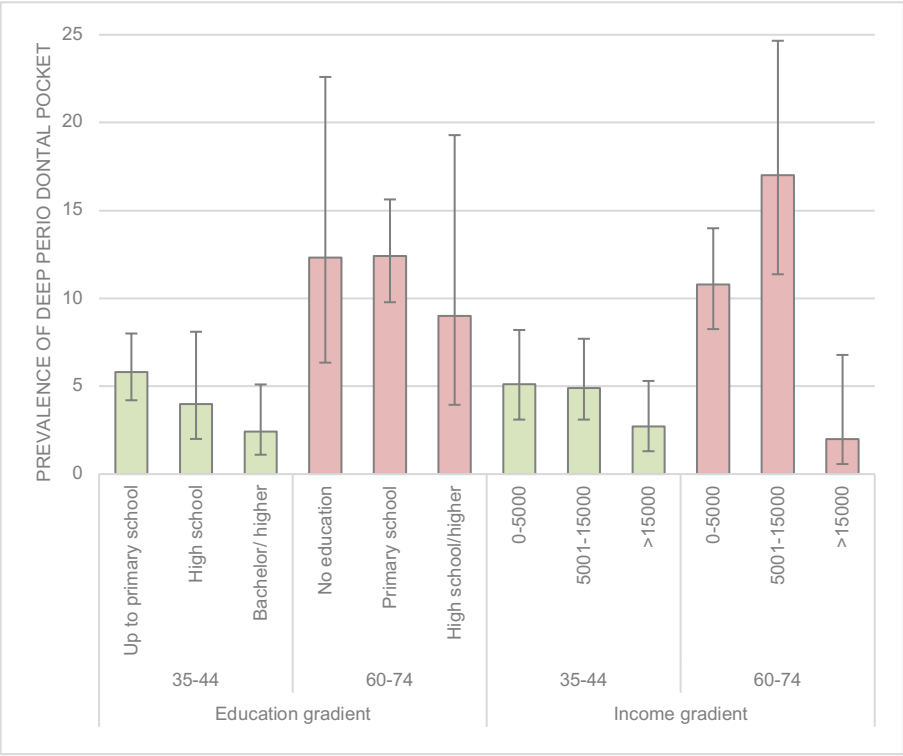

Figure 5-4 Education and income gradient in the presence of deep periodontal pocket among 35-44 and 60-74-year-old adults

5.3.3 Tooth loss

Non-functional dentition

Among age group 35-44 years, having non-functional dentition was significantly associated only with age group (Table 5-4). The prevalence of non-functional dentition was higher among age group 40-44 years (3.5% 95%CI 1.9-6.3) than age group 35-39 years (1.5% 95%CI 0.7-3.5). None of socio-economic factor and oral health-related behaviour was significantly associated with non-functional dentition in this age group.

Among age group 60-74 years, the prevalence of non-functional dentition was also statistically significantly associated with age group. Moreover, the chi-square test for trend also showed significant linear trend of the association between non-functional dentition and age group (p for trend<0.001) (Table 5-5). The lowest prevalence of non-functional dentition was found among age group 60-64 years (30.2%; 95%CI 24.5-36.7). Non-functional dentition was not associated with education and income. The number of a dental visit during the past year was the only oral health behaviour that was statistically significant associated with non-functional dentition. Individuals who had no dental visit had the lowest prevalence of non-functional dentition (34.6%; 95%CI 29.7-39.8), followed by those who had more than one dental visit (46.9%; 95%CI 36.1-58.0), and the highest prevalence of non-functional dentition was found among those who had one dental visit during the past year (48.0%; 95%CI 38.3-57.8).

Although none of the association between education, income and non-functional dentition was found in both age group, Figure 5-5 shows the education gradient in non-functional dentition among the age group 35-44 and the income gradient among both age groups.

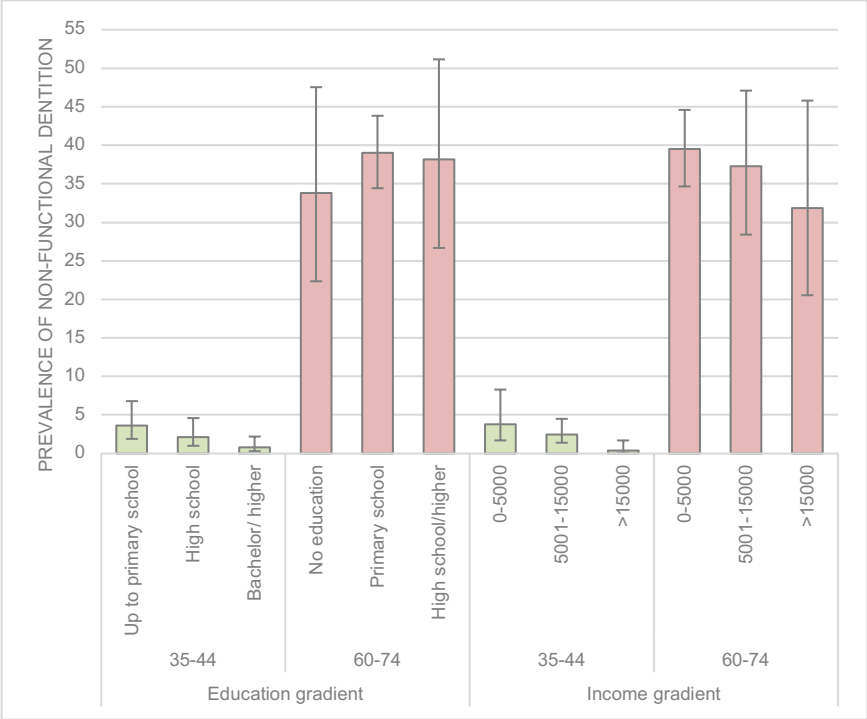

Figure 5-5 Education and income gradient in non-functional dentition among 35-44 and 60-74-year-old adults.

Edentulousness

Edentulousness was significantly associated with age and past year dental visit (Table 5-5). The prevalence of being edentulous was the lowest among age group 60-64 (3.2%; 95%CI 1.6-6.0) and increased in each older age group (p for trend<0.001). Therefore, the highest prevalence was found among age group 70-74 (13.4%; 95%CI 8.3-20.8). In addition, the prevalence of edentulousness was the lowest among participants who had one dental visit during the past year (1.7%; 95%CI 0.5-5.1), followed by who did not visit dentist (8.3%; 95%CI 5.9-11.7) and who had more than one dental visit (9.1%; 95%CI 3.9-19.8). Although, the relationships between edentulousness and both socio-economic factors were non-significant, Figure 5-6 shows the education and income gradients in edentulousness among age group 60-74. The prevalence of being edentulous decreased at each lower level of education and income

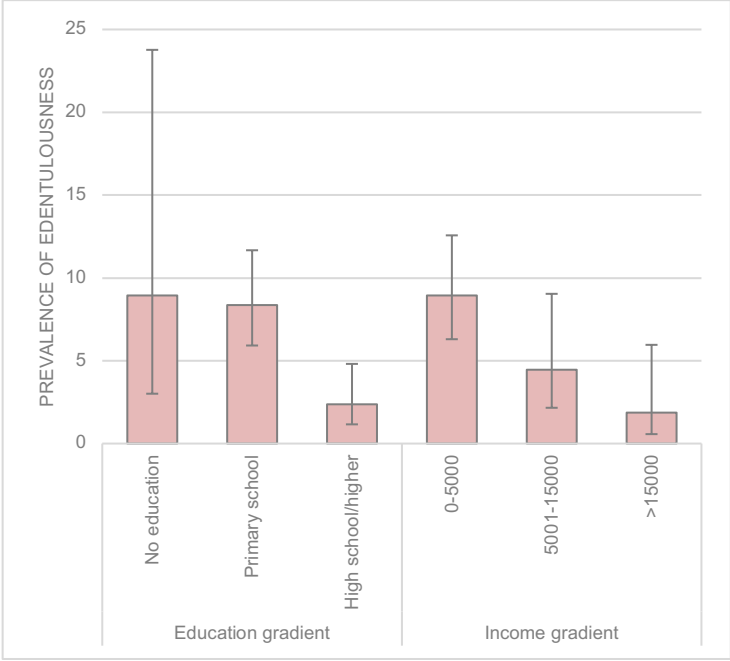

Figure 5-6 Education and income gradient in edentulousness among 60-74-year-old adults.

Table 5-4 The associations between periodontal diseases, non-functional dentition and individual-level characteristics among 35-44-year-old adults (n=1,517)

	Deep periodontal pocket		Non-functional dentition	
	% (95% CI)	p-value/ p for trend	% (95% CI)	p-value/ p for trend
Age group				
35-39	3.2 (2.1-4.7)	0.4617	1.5 (0.7-3.5)	**0.0164**
40-45	5.8 (3.8-8.7)		3.5 (1.9-6.3)	*
Sex				
Male	4.7 (3.3-6.6)	**0.0143**	1.5 (0.7-2.7)	0.3290
Female	4.4 (2.7-7.3)	*	3.6 (1.9-6.6)	
Education				
Up to primary	5.8 (4.2-8.0)	**0.0040**/**	3.6 (1.9-6.8)	0.6031/
High school	4.0 (2.0-8.1)	**0.0101***	2.1 (1.0-4.6)	0.3409
Bachelor/higher	2.4 (1.1-5.1)		0.8 (0.3-2.2)	
Income				
0-5000	5.1 (3.1-8.2)	0.3663/	3.8 (1.7-8.3)	0.1678/
5001-15000	4.9 (3.1-7.7)	0.7224	2.5 (1.4-4.5)	0.2767
>15000	2.7 (1.3-5.3)		0.4 (0.1-1.7)	
Past year dental visit				
No	4.4 (2.8-6.7)	0.4733/	2.7 (1.4-5.0)	0.4559/
1	4.6 (2.5-8.4)	0.2229	2.6 (0.9-7.4)	0.2323
>1	5.3 (2.9-9.5)		2.2 (1.0-5.0)	
Used of F toothpaste				
No	4.7 (2.5-8.7)	0.5120	1.2 (0.5-2.6)	0.6674
Yes	4.5 (3.2-6.4)		3.0 (1.8-5.1)	
Brushing frequency				
<2	7.2 (3.3-15.3)	0.9639	1.6 (0.5-5.3)	0.8688
2 or more	4.3 (3.1-6.0)		2.7 (2.6-4.4)	
Smoking status				
No	4.7 (3.2-6.8)	0.5068/	2.5 (1.4-4.6)	0.9618/
Ex-smoker	3.8 (1.7-8.6)	0.2651	2.2 (0.6-7.4)	0.8881
Current smoker	4.3 (2.4-7.6)		2.8 (1.0-7.6)	

p-value: ***p<0.001; **p<0.01; *<0.05

Table 5-5 The associations between periodontal diseases, tooth loss and individual-level characteristics among 60-74-year-old adults

	Deep periodontal pocket (n=1,143)		Non-functional dentition (n=1,143)		Edentulous (n=1,263)	
	% (95% CI)	p-value/ p for trend	% (95% CI)	p-value/ p for trend	% (95% CI)	p-value/ p for trend
Age group						
60-64	13.9 (10.2-18.5)	0.0948/	30.2 (24.5-36.7)	**<0.001*****/**	3.2 (1.6-6.0)	**<0.001*****/**
65-69	12.3 (8.4-17.8)	**0.0308***	44.9 (37.8-52.3)	**<0.001*****	8.8 (5.2-14.4)	**<0.001****
70-74	6.8 (3.9-11.7)		44.2(35.2-53.7)		13.4 (8.3-20.8)	
Sex						
Male	12.5 (9.2-16.7)	0.4810	35.3 (29.7-41.3)	0.2818	7.1 (4.4-11.4)	0.9244
Female	11.2 (8.1-15.3)		41.8 (35.8-48.0)		7.9 (5.2-11.8)	
Education (%)						
No education	12.3 (6.3-22.6)	0.3922/	33.8 (22.4-47.5)	0.5857/	9.0 (3.0-23.8)	0.8339/
Primary school	12.4 (9.8-15.6)	0.1817	39.0 (34.4-43.8)	0.6718	8.4 (5.9-11.7)	0.9116
High school/higher	9.0 (3.9-19.3)		38.2 (26.7-51.2)		2.4 (1.2-4.8)	
Income						
0-5000	10.8 (8.3-14.0)	**0.0096****	39.5 (34.7-44.6)	0.5219/	9.0 (6.3-12.6)	0.1698/
5001-15000	17.0 (11.4-24.7)	0.3241	37.3 (28.4-47.1)	0.2969	4.5 (2.2-9.0)	0.0746
>15000	2.0 (0.6-6.8)		31.9 (20.5-45.8)		1.9 (0.6-6.0)	
Past year dental visit						
No	11.8 (9.0-15.3)	0.7598/	34.6 (29.7-39.8)	**0.0075****	8.3 (5.9-11.7)	**0.0100***
1	11.7 (7.2-18.3)	0.8141	48.0 (38.3-57.8)	**0.0022****	1.7 (0.5-5.1)	0.1946
>1	12.3 (6.4-22.2)		46.9 (36.1-58.0)		9.1 (3.9-19.8)	
Used of F toothpaste						
No	14.8 (9.6-22.1)	0.2318	39.2 (31.3-47.6)	0.3277		
Yes	11.0 (8.5-14.1)		38.3 (33.5-43.4)			
Brushing frequency						
<2	14.3 (9.7-20.5)	0.1177	41.9 (32.8-51.6)	0.6587		
2 or more	11.3 (8.7-14.6)		37.8 (33.1-42.6)			
Smoking status						
No	12.2 (9.4-15.8)	0.8099/	38.1 (33.2-43.3)	0.2327/	7.5 (5.2-10.6)	0.6095/
Ex-smoker	9.3 (5.1-16.4)	0.8497	34.9 (24.4-47.1)	0.1886	6.2 (1.7-20.0)	0.4888
Current smoker	12.0 (7.4-19.0)		43.4 (33.5-53.7)		8.7 (4.1-17.5)	

p-value: ***p<0.001; **p<0.01; *<0.05

5.4 Associations between oral health outcomes and area-level charateristics

This section reports the associations between oral health outcomes and area-level characteristics in both age groups. Area-level characteristics, used in this chapter, consisted of regions (ordered by regional Poverty Headcount Ratio), tertiles of provincial characteristics (provincial Poverty Headcount Ratio, Dentist per Population ratio, HAI, GINI coefficient), and urban/rural area.

5.4.1 Dental caries experience

DMFT

The results from age group 35-44 years showed that DMFT was significantly associated with all area-characteristics (Table 5-6). At regional level, the highest DMFT was found in the central region (8.2 teeth/person; SD= 5.5), followed by Bangkok region (6.7 teeth/person; SD=8.4), southern region (6.8 teeth/person; SD=3.7), northern region (5.8 teeth/person; SD=4.6), and the lowest DMFT was found in the north-eastern region, which is the poorest region (3.9 teeth/person; SD=4.6). At provincial level, the highest mean DMFT was found among provinces that had moderate Poverty Headcount Ratio, high dentist per population ratio, high human achievement index and low GINI coefficient. In addition, the highest DMFT was found among individuals who lived in urban area (7.4 teeth/person; SD=4.2), followed by those who lived in Bangkok (7.0 teeth/person; SD=8.4), and the lowest DMFT was found among those who lived in rural area (4.6 teeth/person; SD=5.1).

Apart from Bangkok, there was regional gradient in DMFT (Figure 5-7). The lowest mean DMFT was found in the poorest region and was higher at each richer region.

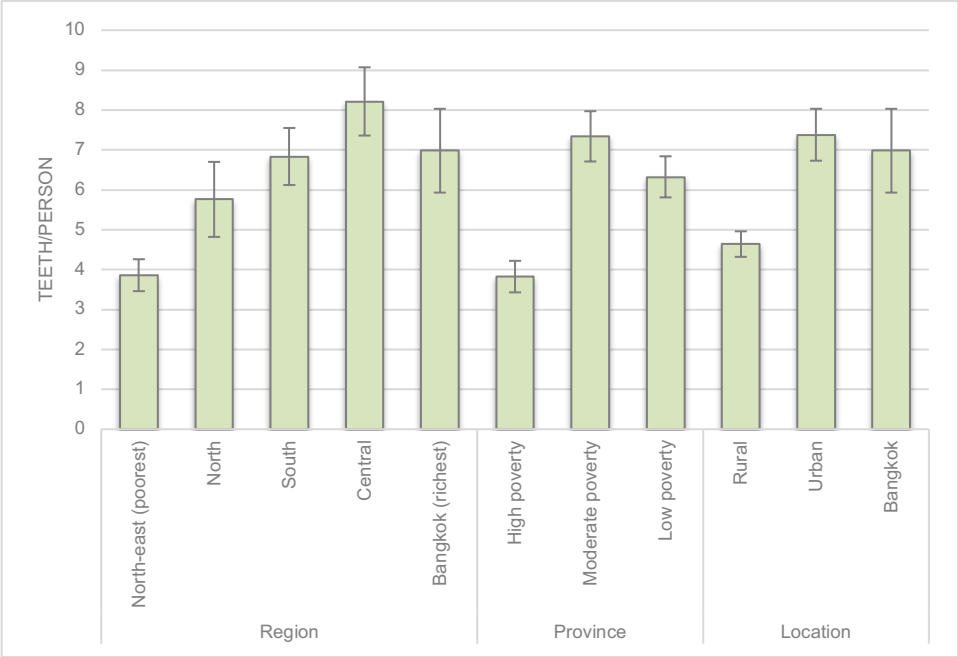

Figure 5-7 The mean number of DMFT by regions, provincial Poverty Headcount Ratio, urban/rural among 35-44-year-old adults.

Decayed teeth

Among age group 35-44 years, the number of decayed teeth was significantly associated with regions and all provincial level characteristics (Table 5-6). The highest mean number of decayed teeth was found in two richest regions, which was Bangkok (1.0 teeth/person; SD=2.7) and central region (1.0 teeth/person; SD=2.0). At provincial level, the highest mean number of decayed teeth was found in provinces that had moderate poverty, high dentist per population ratio, high HAI score and Low GINI coefficient.

Among age group 60-74 years, the number of decayed teeth was significantly associated with type of location only (Table 5-7). The mean number of decayed teeth was highest in the rural area (1.8 teeth/person; SD=3.1), followed by Bangkok (1.6 teeth/person; SD=4.0) and urban area has the lowest mean number of decayed teeth (1.1 teeth/person; SD=1.4).

Figure 5-8 shows none of area-level socio-economic gradient in decayed teeth among 35-44-year-old adults. Among age group 60-74 years, there was the provincial poverty gradient in decayed teeth. However, the statistics showed no significant difference.

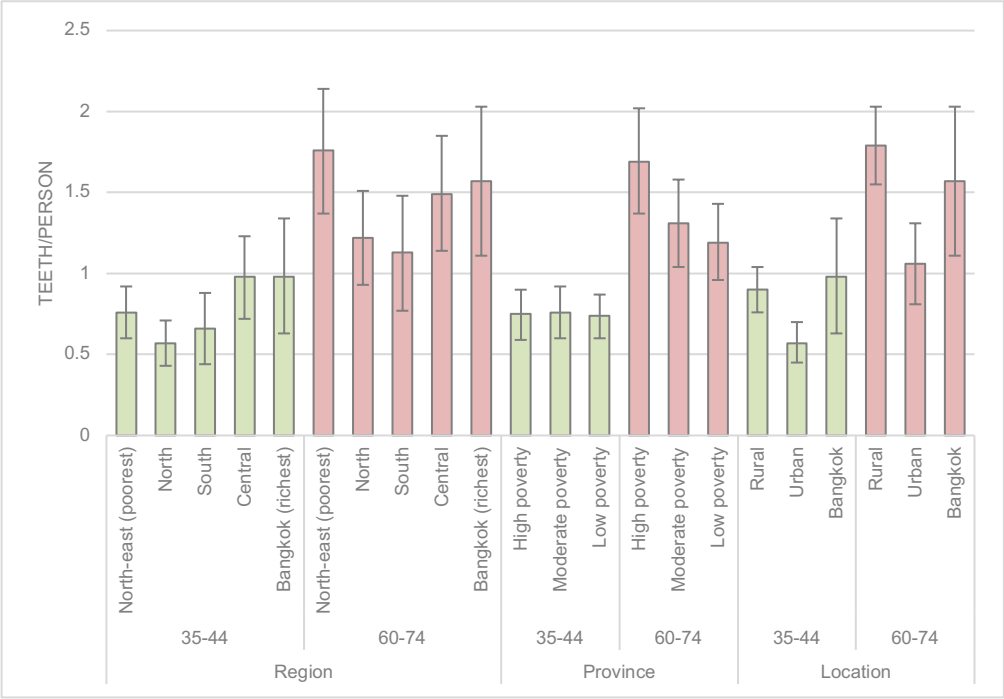

Figure 5-8 Mean number of Decayed teeth by regions, provincial Poverty Headcount Ratio, and urban/rural among 35-44 and 60-74-year-old adults.

Filled teeth

Among age group 35-44 years, the number of filled teeth was associated with all area-level characteristics except HAI score (Table 5-6). At regional level, the mean number of filled teeth was lowest in the north-eastern region, which was the poorest region (0.9 teeth/person; SD=2.5), followed by northern region (1.1 teeth/person; SD=1.9), southern region (2.1 teeth/person; SD=2.3), central region (2.4 teeth/person; SD=3.3). Bangkok, which was the richest region, had the highest mean number of filled teeth (2.4 teeth/person; SD=5.8). At provincial level, the highest mean number of filled teeth was found in provinces that had moderate poverty (2.0 teeth/person; SD=2.3), high dentist per population ratio (1.9 teeth/person; SD=4.0), low GINI coefficient (2.3 teeth/person; SD=3.8). In addition; comparing the number of filled teeth between different type of location, Bangkok had the highest mean number of filled teeth (2.4 teeth/person; SD=5.8), followed by urban area (2.3 teeth/person; SD=2.6) and rural area had the lowest mean number of filled teeth (0.8 teeth/person; SD=2.2).

Similarly, among age group 60-74 years, the number of filled teeth was associated with all area-level characteristics except HAI score (Table 5-7). At regional level, the mean number of filled teeth was the highest in Bangkok (2.0 teeth/person; SD=6.2), followed by central region (0.8 teeth/person; SD=1.9), southern region (0.7 teeth/person; SD=1.7), and was the lowest in the northern (0.2 teeth/person; SD=0.8) and north-eastern region (0.2 teeth/person; SD=1.0). In addition, at provincial level, the highest mean number of filled teeth was found in provinces that had low poverty (1.0 teeth/person; SD=3.2), high dentist per population ratio (1.2 teeth/person; SD=3.8) and low GINI coefficient (1.0 teeth/person; SD=2.9). Furthermore, comparing between urban and rural, rural area had the lowest mean number of filled teeth (0.1

teeth/person; SD=0.9), followed by urban area (0.7 teeth/person; SD=1.3) and Bangkok had the highest mean number of filled teeth (2.0 teeth/person; SD=6.2).

Figure 5-9 shows that there was a clear regional gradient in number of filled teeth in both age groups. Although the lowest mean number of filled teeth was found among high poverty province in both age group, the provincial poverty gradient in filled teeth was found only in age group 60-74 years.

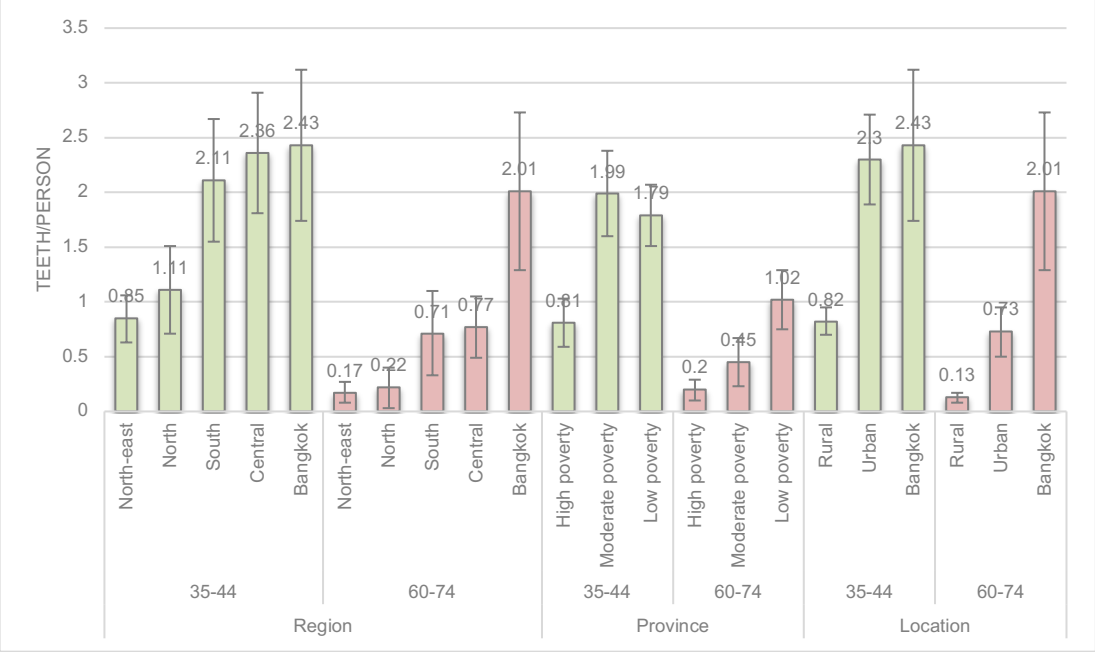

Figure 5-9 Mean number of filled teeth by regions, provincial Poverty Headcount Ratio, and urban/rural among 35-44 and 60-74-year-old adults.

Table 5-6 The associations between dental caries and area-level characteristics among 35-44-year-old adults (n=1,517).

	DMFT		Decayed teeth		Filled teeth	
	Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Regions						
North-east (poorest)	3.9 (4.6)	**<0.001**	0.8 (1.7)	**<0.001**	0.9 (2.5)	**<0.001**
North	5.8 (4.6)	***	0.6 (0.9)	***	1.1 (1.9)	***
South	6.8 (3.7)		0.7 (1.5)		2.1 (2.3)	
Central	8.2 (5.5)		1.0 (2.0)		2.4 (3.3)	
Bangkok (richest)	7.0 (8.4)		1.0 (2.7)		2.4 (5.8)	
Provincial Poverty Headcount Ratio						
High poverty	3.8 (3.9)	**<0.001**	0.8 (1.5)	**0.0209**	0.8 (2.2)	**<0.001**
Moderate poverty	7.3 (4.2)	***	0.8 (1.4)	*	2.0 (2.3)	***
Low poverty	6.3 (7.4)		0.74(2.1)		1.8 (4.2)	
Dentist:Population ratio						
Low	4.3 (5.2)	**<0.001**	0.8 (1.8)	**<0.001**	1.1 (2.9)	**<0.001**
Moderate	6.3 (4.1)	***	0.7 (1.3)	***	1.7 (2.2)	***
High	7.0 (5.9)		0.9 (2.2)		1.9 (4.0)	
Human Achievement Index (HAI)						
Low	5.9 (4.2)	**<0.001**	0.7 (1.5)	**<0.001**	1.9 (2.6)	0.5572
Moderate	5.8 (5.7)	***	0.6 (1.3)	***	1.3 (2.6)	
High	6.6 (6.2)		1.1 (2.5)		1.4 (3.2)	
GINI						
Low	7.9 (6.3)	**<0.001**	1.0 (2.2)	**<0.001**	2.3 (3.8)	**<0.001**
Moderate	5.2 (4.7)	***	0.9 (1.5)	***	1.0 (2.2)	***
High	5.2 (4.0)		0.4 (1.2)		1.5 (2.3)	
Living location type						
Rural	4.6 (5.1)	**<0.001**	0.9 (2.2)	0.2495	0.8 (2.2)	**<0.001**
Urban	7.4 (4.2)	***	0.6 (0.9)		2.3 (2.6)	***
Bangkok	7.0 (8.4)		1.0 (2.7)		2.4 (5.8)	

p-value: ***p<0.001; **p<0.01; *<0.05

Table 5-7 The associations between dental caries and area-level characteristics among 60-74-year-old adults (n=1,143).

	Decayed teeth		Filled teeth	
	Mean (SD)	p-value	Mean (SD)	p-value
Regions				
North-east (poorest)	1.8 (2.6)	0.7161	0.2 (1.0)	**<0.001**
North	1.2 (1.2)		0.2 (0.8)	***
South	1.1 (2.2)		0.7 (1.7)	
Central	1.5 (2.6)		0.8 (1.9)	
Bangkok (richest)	1.6 (4.0)		2.0 (6.2)	
Provincial Poverty Headcount Ratio				
High poverty	1.7 (2.3)	0.0737	0.2 (1.0)	**<0.001**
Moderate poverty	1.3 (2.0)		0.5 (1.0)	***
Low poverty	1.2 (2.7)		1.0 (3.2)	
Dentist:Population ratio				
Low	1.4 (2.0)	0.4120	0.4 (1.0)	**<0.001**
Moderate	1.4 (2.1)		0.3 (1.0)	***
High	1.5 (3.5)		1.2 (3.8)	
Human Achievement Index (HAI)				
Low	1.2 (1.7)	0.2589	0.4 (1.1)	0.4341
Moderate	1.5 (2.6)		0.5 (1.5)	
High	1.7 (3.8)		0.7 (2.8)	
GINI				
Low	1.6 (3.1)	0.2611	1.0 (2.9)	**<0.001**
Moderate	1.6 (2.4)		0.2 (0.9)	***
High	1.1 (1.7)		0.4 (1.2)	
Living location type				
Rural	1.8 (3.1)	**0.0288**	0.1 (0.9)	**<0.001**
Urban	1.1 (1.4)	*	0.7 (1.3)	***
Bangkok	1.6 (4.0)		2.0 (6.2)	

p-value: ***p<0.001; **p<0.01; *<0.05

5.4.2 Periodontal diseases

Having deep periodontal pocket

Among age group 35-44 years, chi-square test showed that having deep periodontal pocket was associated with region and GINI coefficient. However, chi-square test for trend did not find any significant trend of the association (Table 5-8). At the regional level, the highest prevalence of deep periodontal pocket was found in the southern region (6.2% 95%CI 3.1-12.2), followed by north-eastern region (6.1% 95%CI 4.1-9.0), Bangkok (4.4% 95%CI 1.6-11.1), northern region (2.8% 95%CI 1.4-5.7), and was the lowest in the central region (2.6% 95%CI 1.0-7.0). At the provincial level, the highest prevalence of deep periodontal pocket was found in the provinces that had moderate GINI coefficient (6.3%; 95% CI 4.4-8.9).

Among age group 60-74 years, there were statistically significant associations between having deep periodontal pocket and region, provincial Poverty Headcount Ratio, and dentist per population ratio (Table 5-9). At regional level, north-eastern region had the highest prevalence of deep periodontal pocket (17.6%; 95% CI 12.7-23.8) and central region had the lowest prevalence (5.9%; 95% CI 2.8-12.0). At provincial level, the highest prevalence of deep periodontal pocket was found in the provinces that had high poverty (16.5%; 95% CI 12.1-22.0), low dentist per population ratio (16.6%; 95% CI 12.1-22.2). In addition, chi-square test for trend exhibited significant linear trend of the relationships of having deep periodontal pocket and region and provincial poverty (Table 5-9).

Figure 5-10 shows that overall age group 60-74 years had higher prevalence of deep periodontal pocket than age group 35-44. The pattern of the differences in prevalence between regions, provincial Poverty Headcount Ratio, and locations were similar between two age groups. There was provincial Poverty Headcount Ratio gradient in deep periodontal in both age groups. However, the statistically significant linear trend was found only in age group 60-74 years. Moreover, rural area had the highest prevalence of deep periodontal pocket in both age groups.

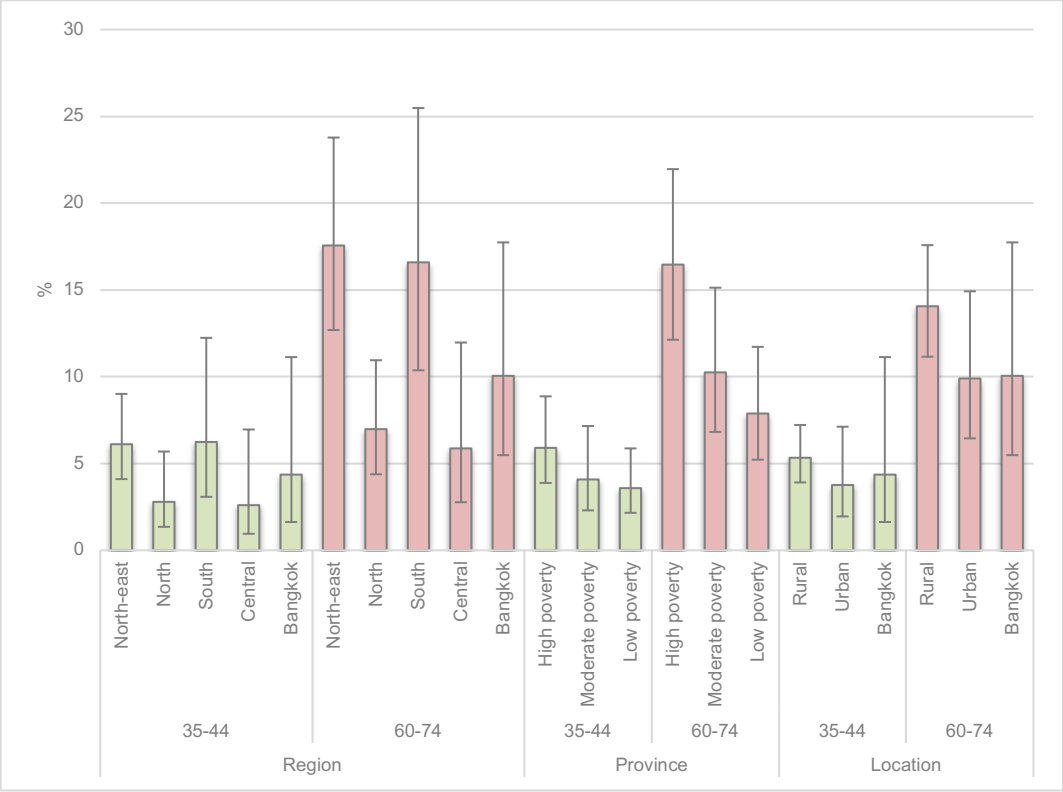

Figure 5-10 The prevalence of periodontal disease (having deep periodontal pocket) by regions, provincial Poverty Headcount Ratio and urban/rural among 35-44 and 60-74-year-old adults

5.4.3 Tooth loss

Non-functional dentition (having less than 20 teeth)

Among adults aged 35-44 years, non-functional dentition was associated with regions and provincial poverty (Table 5-9). At the regional level, about 5% of adults from central (5.2%; 95%CI 2.6-10.2) and northern (4.6%; 95%CI 1.8-10.8), 2% from Bangkok (1.8%; 95%CI 0.4-7.4) and less than 1% from southern (1.0%, 95%CI 0.3-3.1) and north-eastern (0.5%; 95%CI 0.2-1.1) regions had non-functional dentition. At the provincial level, the highest prevalence of non-functional dentition was found in provinces that had moderate poverty (3.93%; 95% CI 2.08-7.32), followed by low poverty (2.6%; 95%CI 1.4-4.8), and high poverty (0.5%; 95%CI 0.2-1.9).

Correspondingly, among adults aged 60-74 years, non-functional dentition was associated with regions, provincial Poverty Headcount Ratio but additionally associated with dentist per population ratio, GINI coefficient, and urban/rural (Table 5-9). At regional level, the prevalence of non-functional dentition ranged from lowest in north-eastern region (26.9%; 95% CI 21.1-33.5) to highest in central region (47.3%; 95% CI 38.9-55.9). The chi-square test for test exhibited statistically significant linear trend in prevalence of non-functional dentition by regions (p-value for trend <0.001). At provincial level, the highest prevalence of non-functional dentition was found in provinces that had moderate poverty (47.8%; SD=40.1-55.6), moderate dentist: population (47.0%; SD=40.2-53.9), and low GINI coefficient (45.2%; 95%CI 37.6-53.1). According to type of location, about a half of those from urban area (47.8%; 95% CI 40.5-55.2), 32% (95% CI 24.0-41.9) of those from Bangkok, and 29% (95% CI 25.2-33.0) of those from rural area had non-functional dentition.

Figure 5-11 shows that over all prevalence of non-functional dentition was lower in age group 35-44 years compared to age group 60-74 years and none of area-level socio-economic gradient in non-functional dentition was found in both age groups.

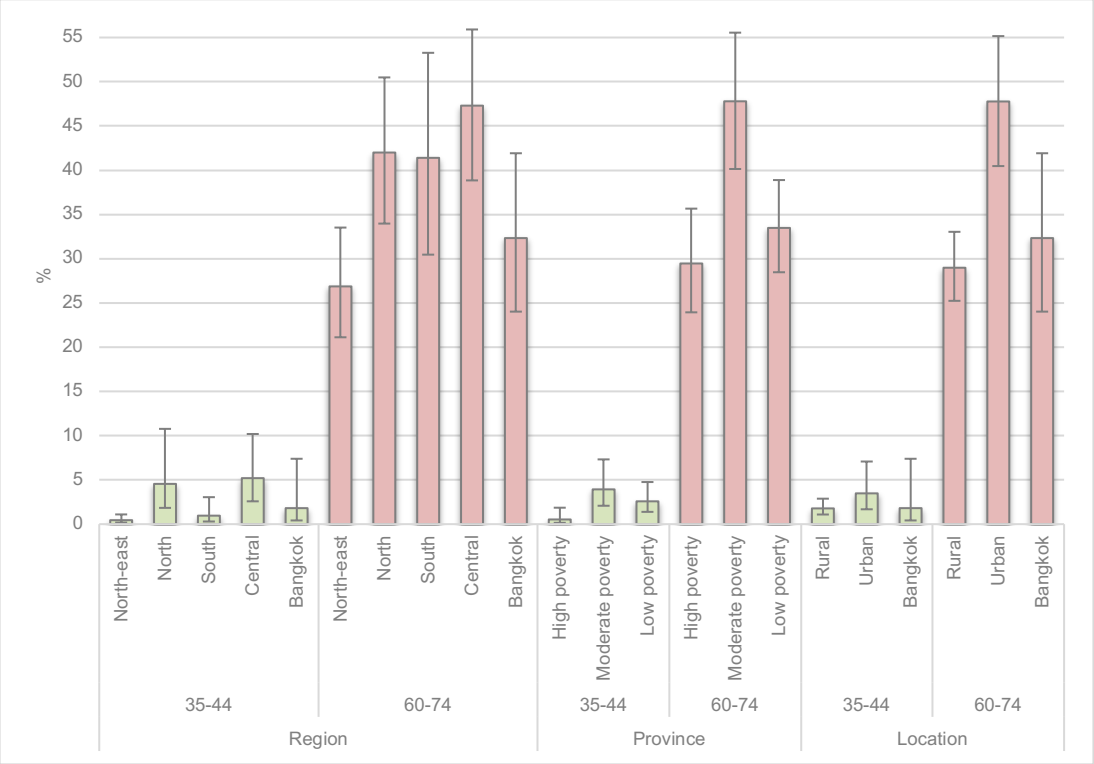

Figure 5-11 The prevalence of non-functional dentition (having less than 20 teeth remaining) by regions, provincial Poverty Headcount Ratio and urban/rural among 35-44 and 60-74-year-old adults

Edentulousness (complete tooth loss)

Among adults age 60-74 years, being edentate was significantly associated with regions, dentist per population ratio, GINI coefficient, and urban/rural area. Additionally, chi-square test for trend showed the significant linear trend of the associations between edentulousness and regions, dentist per population ratio, GINI coefficient, and urban/rural (Table 5-9). At the regional level, the highest prevalence of edentulousness was found in central region (10.9%; 95%CI 6.3-18.2), followed by Bangkok (10.1%; 95% CI 5.9-16.7), southern (9.3% 95%CI 4.7-17.6), northern (6.5%;

95%CI 3.3-12.7), and was the lowest in north-eastern region (3.7%; 95%CI 1.8-7.3). At the provincial level, the highest prevalence of edentulousness was found in provinces that had high dentist per population ratio (10.2%; 95%CI 7.1-14.3) and low GINI coefficient (11.8%; 95%CI 7.4-18.1). In addition, the prevalence in edentulousness was significantly higher in urban area (10.0%; 95%CI 6.4-15.1) compared to rural area (4.5%; SD=3.1-6.5).

Figure 5-12 shows regional gradient in edentulousness among 60-74-year-old adults. The bar graph shows that the prevalence of older adults who were edentate was the lowest in more deprived or rural area.

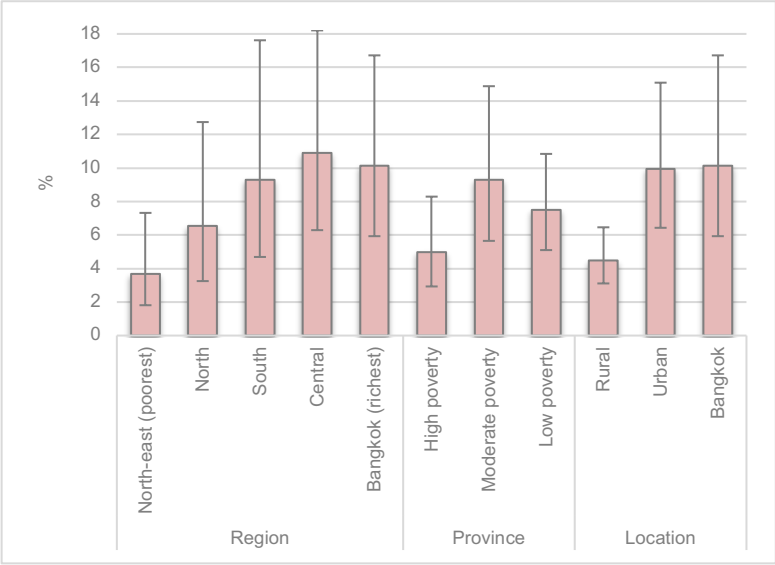

Figure 5-12 The prevalence of edentulousness by regions, provincial Poverty Headcount Ratio and urban/rural among 60-74-year-old adults

Table 5-8 The associations between periodontal disease, non-functional dentition and area-level characteristics among 35-44-year-old adults (n=1,517)

	Deep periodontal pocket		Non-functional dentition	
	% (95% CI)	p-value/ p for trend	% (95% CI)	p-value/ p for trend
Regions				
North-east (poorest)	6.1 (4.1-9.0)	**0.0021**/**	0.5 (0.2-1.1)	**0.0090**/**
North	2.8 (1.4-5.7)	0.2360	4.6 (1.8-10.8)	**0.0318***
South	6.2 (3.1-12.2)		1.0 (0.3-3.1)	
Central	2.6 (1.0-7.0)		5.2 (2.6-10.2)	
Bangkok (richest)	4.4 (1.6-11.1)		1.8 (0.4-7.4)	
Provincial Poverty Headcount Ratio				
High poverty	5.9 (3.9-8.9)	0.1649/	0.5 (0.2-1.9)	**0.0271*/**
Moderate poverty	4.1 (2.3-7.2)	0.1369	3.9 (2.1-7.3)	0.1316
Low poverty	3.6 (2.2-5.9)		2.6 (1.4-4.8)	
Dentist:Population ratio				
Low	5.6 (3.5-9.1)	0.1526/	0.6 (0.2-1.5)	0.0617/
Moderate	3.6 (2.0-6.3)	0.2486	3.3 (1.7-6.1)	0.3220
High	6.2 (4.2-9.0)		2.7 (1.4-5.3)	
Human Achievement Index (HAI)				
Low	4.8 (2.9-8.0)	0.4541/	1.5 (0.5-4.0)	0.0913/
Moderate	3.8 (2.4-6.0)	0.7213	4.0 (2.0-7.9)	0.3240
High	5.4 (3.4-8.3)		2.8 (1.3-5.8)	
GINI				
Low	3.4 (1.8-6.3)	**0.0026**/**	4.4 (2.4-8.1)	0.1326/
Moderate	6.3 (4.4-8.9)	0.6995	2.5 (0.9-6.8)	0.0959
High	3.9 (1.8-7.9)		1.1 (0.5-2.3)	
Living location type				
Rural	5.3 (3.9-7.2)	0.3873/	1.8 (1.1-2.9)	0.7124/
Urban	3.8 (2.0-7.1)	0.1685	3.5 (1.7-7.1)	0.9976
Bangkok	4.4 (1.6-11.1)		1.8 (0.4-7.4)	

p-value: ***p<0.001; **p<0.01; *<0.05

Table 5-9 The associations between periodontal diseases, tooth loss and area-level characteristics among 60-74-year-old adults

	Deep periodontal pocket (n=1,143)		Non-functional dentition (n=1,143)		Edentulousness (n=1,263)	
	% (95% CI)	p-value/ p for trend	% (95% CI)	p-value/ p for trend	% (95% CI)	p-value/ p for trend
Regions						
North-east(poorest)	17.6 (12.7-23.8)	**<0.001*****/	26.9 (21.1-33.5)	**<0.001*****/	3.7 (1.8-7.3)	**0.0019****/
North	7.0 (4.4-11.0)	**0.0190***	42.0 (34.0-50.5)	**<0.001*****	6.5 (3.3-12.7)	**0.0029****
South	16.6 (10.4-25.5)		41.4 (30.5-53.3)		9.3 (4.7-17.6)	
Central	5.9 (2.8-12.0)		47.3 (38.9-55.9)		10.9 (6.3-18.2)	
Bangkok (richest)	10.1 (5.517.8)		32.3 (24.0-41.9)		10.1 (5.9-16.7)	
Provincial Poverty Headcount Ratio						
High poverty	16.5 (12.1-22.0)	**0.0037****/	29.5 (23.9-35.7)	**<0.001*****	5.0 (2.9-8.3)	0.1891/
Moderate poverty	10.3 (6.8-15.1)	**0.0021****	47.8 (40.1-55.6)	0.1176	9.3 (5.7-14.9)	0.0706
Low poverty	7.9 (5.2-11.7)		33.5 (28.5-38.9)		7.5 (5.1-10.8)	
Dentist:Population ratio						
Low	16.6 (12.1-22.2)	**<0.001***/	31.6 (25.0-38.9)	**0.0011****/	5.2 (2.7-10.1)	**0.0012****/
Moderate	6.0 (3.7-9.5)	0.3840	47.0 (40.2-53.9)	**0.0093****	8.7 (5.3-14.0)	**<0.001*****
High	13.1 (9.5-17.8)		37.2 (31.4-43.3)		10.2 (7.1-14.3)	
Human Achievement Index (HAI)						
Low	14.7 (10.6-19.9)	0.0961	36.3 (29.7-43.4)	0.9707/	8.1 (4.9-12.9)	0.1730/
Moderate	8.6 (6.0-12.2)	0.2806	42.0 (35.5-48.8)	0.9310	6.4 (3.6-11.0)	0.5846
High	10.2 (7.3-14.1)		37.7 (32.0-43.7)		8.1 (5.6-11.7)	
GINI						
Low	8.7 (5.4-13.8)	0.1512/	45.2 (37.6-53.1)	**<0.001*****/	11.8 (7.4-18.1)	**0.0027****/
Moderate	12.5 (9.0-17.2)	0.0592	39.7 (33.3-46.4)	**<0.001*****	6.8 (4.2-11.0)	**<0.001*****
High	13.1 (9.0-18.7)		33.1 (26.0-41.1)		5.2 (2.4-10.8)	
Living location type						
Rural	14.7 (11.2-17.6)	0.5644/	29.0 (25.2-33.0)	**<0.001*****/	4.5 (3.1-6.5)	**0.0420***/
Urban	9.9 (6.5-14.9)	0.2905	47.8 (40.5-55.2)	**0.0299***	10.0 (6.4-15.1)	**0.0125***
Bangkok	10.1 (5.5-17.7)		32.3 (24.0-41.9)		10.1 (5.9-16.7)	

p-value: ***p<0.001; **p<0.01; *<0.05

5.5 Associations between oral health-related behaviours and socio-economic measures

This section shows the associations between oral health-related behaviours and socio-economic measures at both individual and area levels. Oral health-related behaviours, used in this study, were brushing at least twice a day, used of fluoride toothpaste, dental visit during the past year, and smoking status. Individual-level socio-economic measures consisted of education and income. Area-level characteristics consisted of regions (ordered by regional Poverty Headcount Ratio), tertiles of provincial characteristics (Poverty Headcount Ratio, Dentist per Populations ratio, HAI, GINI coefficient), and urban/rural.

5.5.1 Brushing at least twice a day

Among adults, aged 35-44 years, brushing at least twice a day was significantly associated with sex, education, income, GINI coefficient, and urban/rural (Table 5-10). Chi-square test for trend showed significant linear trend of the relationships between brushing twice a day and education and income (p-value for trend<0.001). The highest proportion was found in high education (96.5%; 95% CI 91.4-98.6) and high-income groups (97.2%; 95% CI 94.6-98.6). According to area-level factors, the provinces, which had high GINI coefficient, had highest prevalence of those who brushed twice a day (94.4%; 95% CI 90.6-96.7). Moreover, brushing twice a day was also associated with urban/rural. The proportion of those who brushed at least twice a day was lower in rural area (88.5%; 95% CI 86.0-90.7) than in urban area (96.1%; 95% CI 92.4-98.0) and Bangkok (96.6%; 95% CI 91.9-98.6).

In age group 60-74 years, over all prevalence of brushing at least twice a day was lower compared to age groups 35-44 years (Table 5-11). At individual level, the

highest proportion of brushing twice a day was found among high education group (92.2%; 95% CI 85.7-95.8). Chi-square test for trend also showed significant linear association between education and brushing twice a day (p-value for trend=0.0461). At area level, brushing twice a day was associated with region (p-value for trend=0.0027). North-eastern region, which was the poorest region, had lowest proportion of brushing twice a day (72.7%; 95% CI 66.2-78.4), while Bangkok, which was the richest region, had highest proportion (96.6%; 95% CI 91.9-98.6). Brushing twice a day was also associated with dentist per population ratio and GINI coefficient. The highest proportion of brushing twice a day was found in provinces which had high dentist per population ratio (89.9%; 95% CI 86.1-95.6) and low GINI coefficient (85.1%; 95% CI 78.5-90.0). In addition, similar to age group 35-44, the association between brushing twice a day was also associated with urban/rural. The proportion of those who brushed at least twice a day was lower in rural area (73.8%; 95% CI 69.7-77.6) than in urban area (96.1%; 95% CI 92.4-98.0) and Bangkok (96.6%; 95% CI 91.9-98.6).

Figure 5-13 shows both individual- and area-level socio-economic gradients in brushing twice a day among age group 35-44 years, however, statistically significant trends were found only for education, income and urban/rural factors. Among adults aged 60-74 years, although Figure 5-13 did not show clearly stepwise association, the highest proportion of elders who brushed their teeth at least twice a day was found among high socio-economic group at both individual- and area-level.

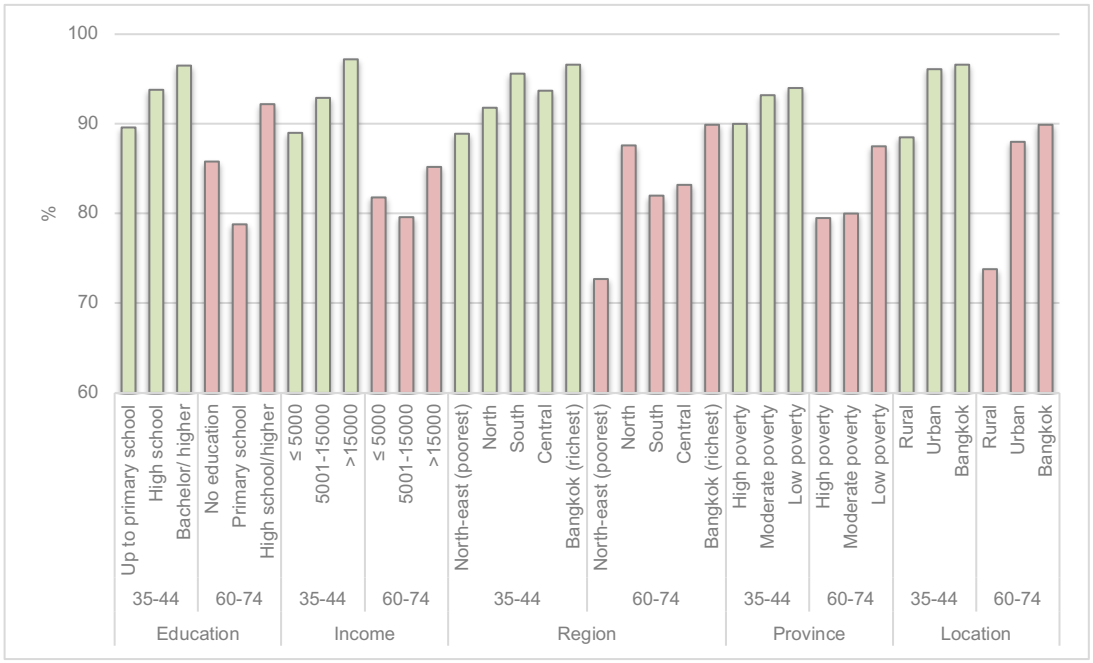

Figure 5-13 Percentage of 35-44 and 60-74-year-old adults who brushed their teeth at least twice a day by individual and area-level socio-economic factors.

Table 5-10 The associations between tooth brushing habits and both individual- and area-level characteristics among 35-44-year-old adults (n=1,517)

Variables	Brushing >2 times/ day		Used fluoride toothpaste	
	% (95% CI)	p-value	% (95% CI)	p-value
Age group (years)				
35-39	90.0 (86.4-92.7)	0.1562	75.7 (70.8-79.9)	0.8404
40-45	94.5 (92.6-95.9)		78.7 (74.6-82.3)	
Sex				
Male	91.3 (88.2-93.6)	**0.0447***	77.6 (72.8-81.8)	0.0980
Female	93.4 (90.8-95.2)		76.9 (72.8-80.6)	
Education				
Up to primary school	89.6 (86.6-92.0)	**<0.001***/	80.8 (76.9-84.2)	**0.0026**/**
High school	93.8 (90.3-96.1)	**<0.001****	75.1 (69.7-79.8)	**<0.001****
Bachelor/higher	96.5 (91.4-98.6)		72.7 (62.8-80.7)	
Income (THB)				
0-5000	89.0 (85.7-91.5)	**<0.001***/	82.2 (78.0-85.7)	**0.0105*/**
5001-15000	92.9 (89.5-95.3)	**<0.001****	73.5 (68.3-78.0)	**0.0033****
>15000	97.2 (94.6-98.6)		78.0 (70.3-84.1)	
Regions				
North-eastern	88.9 (85.4-91.6)	0.0627/	78.6 (74.5-82.2)	**0.0112*/**
North	91.8 (87.1-94.9)	**0.0497***	82.2 (75.1-87.6)	**0.0039****
South	95.6 (88.9-98.4)		76.4 (66.8-83.9)	
Central	93.7 (89.9-96.1)		72.2 (65.5-78.1)	
Bangkok	96.6 (91.9-98.6)		71.4 (62.8-78.8)	
Provincial Poverty Headcount Ratio				
High poverty	90.0 (86.6-92.6)	0.2287/	80.9 (76.5-84.5)	**0.0437*/**
Moderate poverty	93.2 (89.8-95.6)	0.1343	76.2 (70.5-81.2)	**0.0226***
Low poverty	94.0 (91.8-95.7)		74.1 (69.8-77.9)	
Dentist:Population ratio				
Low	87.4 (83.1-90.8)	0.2504/	77.6 (72.8-81.9)	0.4041/
Moderate	93.8 (90.9-95.9)	0.1031	78.5 (73.6-82.7)	0.2481
High	93.3 (90.4-95.4)		73.6 (68.8-77.8)	
HAI				
Low	92.4 (89.1-94.7)	0.7983	80.2 (75.0-84.6)	**0.0011**/**
Moderate	92.0 (88.8-94.3)	0.7181	78.3 (73.5-82.5)	**<0.001****
High	93.1 (89.6-95.4)		66.7 (61.1-71.9)	
GINI				
Low	93.9 (91.0-95.9)	**0.0287*/**	71.6 (66.4-76.3)	**0.0084**/**
Moderate	89.1 (85.4-92.0)	0.8402	79.6 (74.7-83.8)	**0.0097****
High	94.4 (90.6-96.7)		79.8 (73.4-84.9)	
Living Location				
Rural	88.5 (86.0-90.7)	**<0.001***/	79.3 (76.3-82.1)	**0.0204*/**
Urban	96.1 (92.4-98.0)	**<0.001****	75.6 (69.6-80.7)	**0.0065****
Bangkok	96.6 (91.9-98.6)		71.4 (62.8-78.8)	

p-value: ***p<0.001; **p<0.01; *<0.05

Table 5-11 The associations between tooth brushing habits and both individual- and area-level characteristics among 60-74-year-old adults (n=1,143)

Variables	Brushing >2 times/ day		Used fluoride toothpaste	
	% (95% CI)	p-value	% (95% CI)	p-value
Age group (years)				
60-64	81.8 (76.3-86.3)	0.1697/	78.3 (73.1-82.8)	0.7290/
65-69	82.0 (76.2-86.6)	0.0938	75.3 (68.5-81.0)	0.8015
70-74	79.8 (72.4-85.5)		76.4 (67.9-83.2)	
Sex				
Male	78.7 (73.7-83.0)	**<0.001*** **	78.4 (73.2-82.8)	0.2046
Female	84.2 (79.5-88.0)		75.2 (69.9-79.9)	
Education				
No education	85.8 (76.0-91.8)	**0.0111*/**	74.2 (61.3-83.9)	0.0687/
primary school	78.8 (74.7-82.3)	**0.0461***	76.7 (72.5-80.4)	0.3128
High school/higher	92.2 (85.7-95.8)		78.5 (67.9-86.3)	
Income (THB)				
0-5000	81.8 (78.1-85.1)	0.8528/	77.6 (73.4-81.4)	0.5522/
5001-15000	79.6 (70.7-86.3)	0.8289	75.7 (67.0-82.7)	0.3050
>15000	85.2 (74.6-91.9)		71.8 (57.0-83.1)	
Regions				
North-eastern	72.7 (66.2-78.4)	**0.0097**/**	73.1 (66.5-78.9)	0.0824/
North	87.6 (82.0-91.7)	**0.0027****	76.5 (69.1-82.6)	0.2870
South	82.0 (72.0-89.0)		76.1 (65.5-84.2)	
Central	83.2 (75.8-88.7)		83.2 (76.2-88.5)	
Bangkok	89.9 (82.6-94.3)		73.9 (64.5-81.5)	
Provincial Poverty Headcount Ratio				
High poverty	79.5 (73.9-84.2)	**<0.001***/**	72.4 (66.2-77.8)	0.1795/
Moderate poverty	80.0 (73.8-85.1)	**0.0065****	81.3 (74.6-86.5)	0.9560
Low poverty	87.5 (83.7-90.5)		74.6 (69.4-79.2)	
Dentist: Population ratio				
Low	75.7 (69.5-81.0)	**<0.001***/**	75.5 (69.0-81.0)	**0.0013**/**
Moderate	84.3 (79.1-88.4)	**<0.001****	81.3 (75.4-86.0)	0.1898
High	89.8 (86.1-95.6)		70.1 (64.2-75.5)	
HAI				
Low	79.9 (74.1-84.7)	0.5199/	78.5 (72.4-83.6)	0.9210/
Moderate	82.4 (77.4-86.5)	0.2543	74.7 (68.7-79.9)	0.6999
High	84.2 (79.4-88.0)		76.2 (70.8-80.8)	
GINI				
Low	85.1 (78.5-90.0)	**0.0080**/**	79.8 (73.4-84.9)	0.7841/
Moderate	76.6 (71.0-81.3)	0.1902	75.0 (69.1-80.1)	0.8216
High	84.4 (78.3-89.1)		76.9 (70.0-82.6)	
Living Location				
Rural	73.8 (69.7-77.6)	**<0.001***/**	76.4 (72.3-80.0)	0.4622/
Urban	88.0 (82.1-92.2)	**<0.001**	77.4 (71.0-82.8)	0.2720
Bangkok	89.9 (82.6-94.3)		73.8 (64.5-81.5)	

p-value: ***p<0.001; **p<0.01; *<0.05

5.5.2 Use of fluoride toothpaste

Among age group 35-44 years, used of fluoride toothpaste was associated with both individual- and area-level socio-economic factors (Table 5-10). At individual- level, adults aged 35-44 years who belonged to low education and income group had the highest proportion of those who used fluoride toothpaste. In addition, chi-square test for trend showed statistically significant linear trend of associations between education, income and fluoride toothpaste usage (p-value for trend<0.01). At area-level, used of fluoride tooth paste was associated with region, provincial Poverty Headcount Ratio, HAI, GINI coefficient and urban/rural. Proportions of adults who used fluoride toothpaste were higher among those who living in poorer region, low socio-economic province or rural area. Chi-square test for trend also showed statistically significant linear trend of associations between used of fluoride toothpaste and all area-level factors except dentist: population ratio. Among age group 60-74 years, used of fluoride toothpaste was associated with only dentist per population ratio (Table 5-11).

Figure 5-14 shows reverse socio-economic gradients in using fluoride toothpaste in age group 35-44 years while it shows inconsistent pattern of the association in age group 60-74 years.

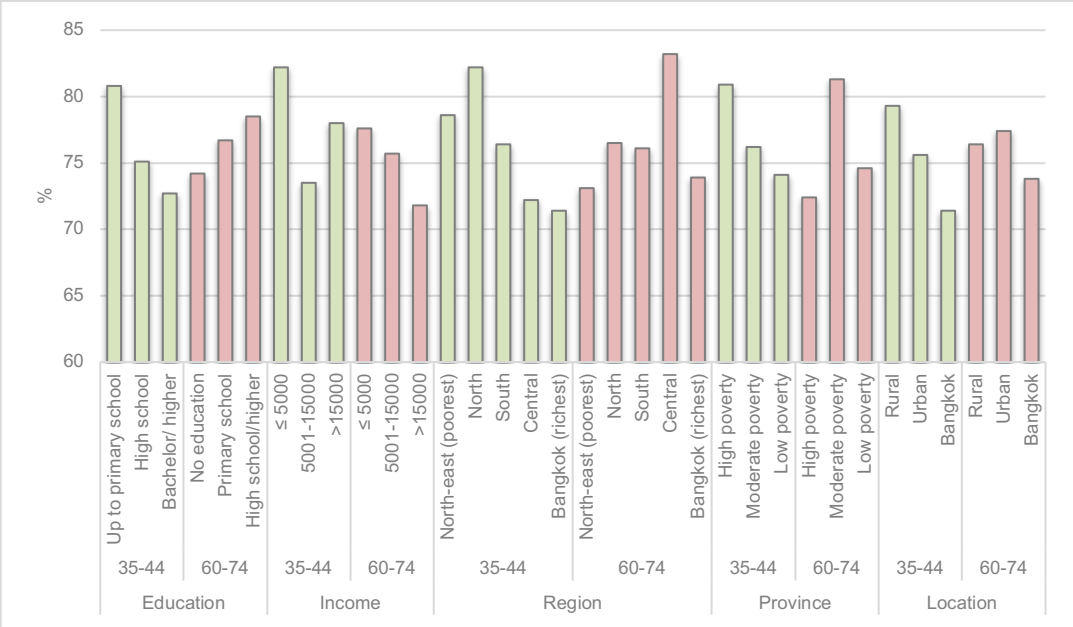

Figure 5-14 Percentage of 35-44 and 60-74-year-old adults who used fluoride toothpaste by individual- and area-level socio-economic factors.

5.5.3 Dental visit during the past year

Among age group 35-44 years, the number of dental visit during the past year was associated with education, income, regions, provincial Poverty Headcount Ratio, GINI coefficient and urban/rural (Table 5-12). Individuals with high education and income more likely to visit dentist during the past year. Only 40% of individual from high education group and 60% from high-income group did not visit dentist during the past year, while the prevalence of individuals who did not visit dentist during the past year was 70% for low education and low-income group. In addition, individuals with high education and income were more likely to had more than one dental visit during the past year. At area-level, individuals who lived in poor and rural area were more likely not to visit dentist during the past year.

Among age group 60-74 years, the number of dental visit during the past year was associated with education, income, region and urban/rural (Table 5-13). Only 56% of high education group and 53% of high income group did not visit dentist during the past year while 70% of both low education and income groups did not visit dentist during the past year. Moreover, the proportion of individuals, who had more than one dental visit, increased at each higher level of education and income. At area-level, only a half of individuals who lived in Bangkok region did not visit dentist during the past year while around 70% of those who lived in poorer region, for example, north and north-eastern regions, and rural area did not visit dentist during the past year.

Figure 5-15 shows clear education and income gradients in number of dental visit during the past year for both age groups. Individuals who belonged to high socio-economic group more likely to visit dentist during the past year. According to area level factor, although the graph does not show the clear stepwise gradient, it shows that individuals who lived in poor or rural area less likely to visit dentist during the past year.

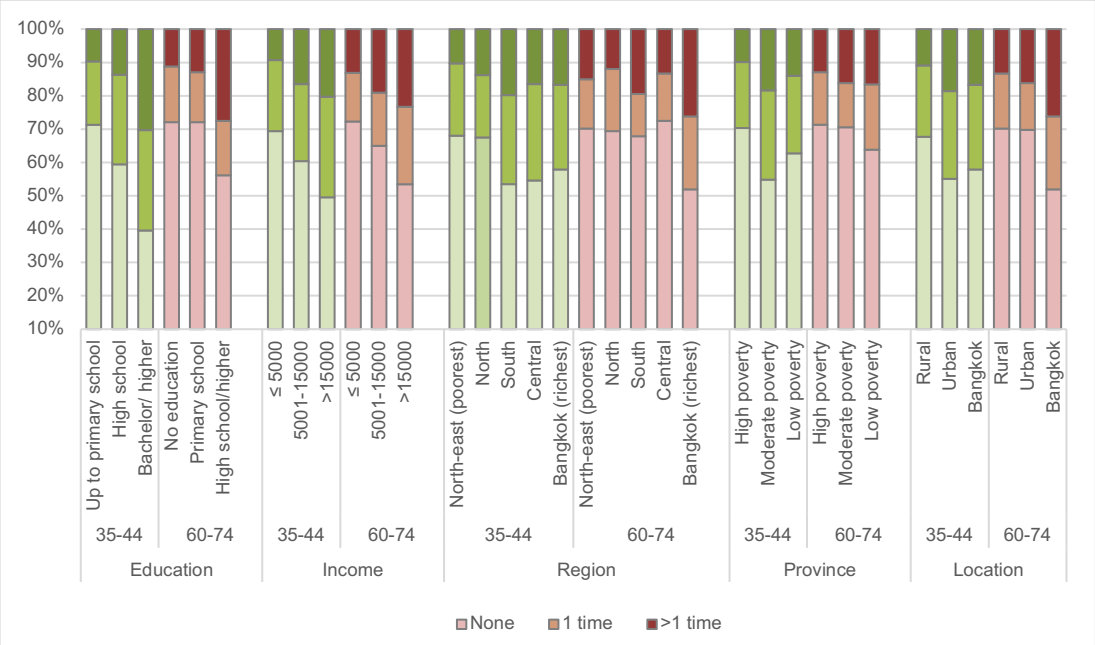

Figure 5-15 Proportion of the number of dental visit during the past year by individual and area-level socio-economic factors.

Table 5-12 The associations between dental visit during the past year and both individual- and area-level characteristics among 35-44-year-old adults (n=1,517)

Variables	Dental visit during the past year			
	None	1time	>1time	
	% (95% CI)	% (95% CI)	% (95% CI)	p-value
Age group (years)				
35-39	61.2 (55.3-66.3)	22.6 (18.6-27.2)	16.2 (12.1-21.2)	0.5290
40-45	61.6 (56.5-66.5)	24.9 (20.6-29.7)	13.5 (10.5-17.3)	
Sex				
Male	64.7 (59.2-69.8)	21.5 (17.3-26.3)	13.9 (10.0-18.8)	**<0.001*** **
Female	58.5 (53.6-63.3)	25.9 (21.8-30.6)	15.6 (12.3-19.5)	
Education				
Up to primary school	71.3 (66.5-75.6)	19.0 (15.3-23.3)	9.7 (7.1-13.2)	**<0.001*** **
High school	59.5(53.6-65.1)	26.9 (21.9-32.6)	13.7 (10.3-17.9)	
Bachelor/higher	39.6 (30.1-50.0)	30.1 (21.5-40.3)	30.3 (21.0-41.5)	
Income (THB)				
0-5000	69.4 (64.1-74.2)	21.3 (17.1-26.2)	9.3 (6.7-12.8)	**0.0020** **
5001-15000	60.4 (54.9-65.6)	23.1(18.8-28.0)	16.5 (12.6-21.3)	
>15000	49.6 (40.1-59.0)	30.2 (22.1-39.7)	20.3 (13.2-29.8)	
Regions				
North-eastern	68.1 (63.5-72.3)	21.7 (18.0-25.8)	10.3 (7.7-13.5)	**0.0070** **
North	67.5 (59.5-74.6)	18.7 (13.5-25.3)	13.8 (8.7-21.3)	
South	53.5 (43.1-63.6)	26.7 (18.5-37.0)	19.8 (12.7-29.5)	
Central	54.6 (47.1-61.9)	28.9 (22.4-36.5)	16.5 (11.5-23.2)	
Bangkok	57.9 (78.8-66.5)	25.4 (18.2-34.3)	16.7 (11.1-24.3)	
Provincial Poverty Headcount Ratio				
High poverty	70.4 (65.6-74.8)	19.8 (16.1-24.1)	9.9 (7.3-13.3)	**0.0180** **
Moderate poverty	54.9 (48.3-61.2)	26.8 (21.4-32.9)	18.4 (13.7-24.2)	
Low poverty	62.8 (58.2-67.1)	23.3 (19.6-27.4)	14.0 (11.0-17.5)	
Dentist:Population ratio				
Low	66.1 (60.7-71.1)	22.4 (18.2-27.3)	11.5 (8.4-15.4)	0.0680
Moderate	60.4 (54.6-65.9)	24.0 (19.4-29.3)	15.7 (11.7-20.7)	
High	59.6 (54.6-64.4)	24.9 (20.8-29.4)	15.5 (12.3-19.4)	
HAI				
Low	58.7 (52.6-64.6)	25.3 (20.3-31.1)	15.9 (11.8-21.2)	0.3850
Moderate	65.6 (60.0-70.8)	20.2 (16.3-24.8)	14.2 (10.3-19.2)	
High	60.7 (55.1-66.1)	26.8 (22.0-32.1)	12.5 (9.4-16.6)	
GINI				
Low	55.1 (49.3-60.8)	28.9 (23.7-34.6)	16.1 (12.1-21.0)	**0.0280***
Moderate	66.1 (60.4-71.4)	20.7 (16.6-25.5)	13.2 (9.4-18.2)	
High	62.1 (54.8-69.0)	22.6 (17.0-29.5)	15.3 (10.5-21.7)	
Living Location				
Rural	67.7 (64.2-71.0)	21.4 (18.6-24.5)	10.9 (8.9-13.4)	**0.0160***
Urban	55.1 (48.3-61.7)	26.3 (20.8-32.7)	18.6 (13.8-24.7)	
Bangkok	57.9 (48.8-66.5)	25.4 (18.2-34.3)	16.7 (11.1-24.3)	

Table 5-13 The associations between dental visit during the past year and both individual- and area-level characteristics among 60-74-year-old adults (n=1,143)

Variables	Dental visit during the past year			
	None	1time	>1time	
	% (95% CI)	% (95% CI)	% (95% CI)	p-value
Age group (years)				
60-64	69.8 (63.9-75.1)	14.9 (11.5-19.1)	15.3 (11.1-20.8)	0.4300
65-69	69.3 (62.4-75.4)	16.3 (11.9-21.9)	14.5 (10.0-20.4)	
70-74	68.7 (59.6-76.6)	15.2 (9.5-22.4)	16.1 (10.7-23.6)	
Sex				
Male	71.2 (65.5-76.3)	14.8 (11.2-19.3)	14.1 (10.3-18.9)	0.0810
Female	67.6 (61.9-72.7)	16.2 (12.5-20.5)	16.3 (12.4-21.2)	
Education				
No education	72.0 (58.9-82.2)	16.8 (9.2-28.7)	11.2 (5.2-22.5)	**<0.001*** **
primary school	72.0 (67.9-75.7)	15.1 (12.4-18.3)	12.9 (10.3-16.1)	
High school/higher	56.2 (43.2-68.4)	16.3 (8.8-25.2)	27.5 (17.3-40.7)	
Income (THB)				
0-5000	72.3 (67.8-76.4)	14.7 (11.7-18.2)	13.1 (10.1-16.7)	**0.0150***
5001-15000	65.0 (55.5-73.4)	15.9 (10.5-23.2)	19.1 (12.5-28.2)	
>15000	53.4 (40.1-66.2)	23.3 (13.1-38.0)	23.3 (14.2-35.9)	
Regions				
North-eastern	70.2 (63.8-76.0)	14.7 (10.6-20.1)	15.1 (11.1-20.3)	**0.0400***
North	69.4 (61.5-76.3)	18.8 (13.4-25.6)	11.9 (7.3-18.8)	
South	68.0 (56.2-77.8)	12.7 (7.1-21.5)	19.4 (11.4-31.0)	
Central	72.5 (65.2-78.7)	14.2 (9.6-20.3)	13.4 (9.4-18.7)	
Bangkok	51.8 (42.2-61.3)	22.0 (15.1-31.1)	26.1 (18.5-35.5)	
Provincial Poverty Headcount Ratio				
High poverty	71.4 (65.4-76.6)	15.8 (11.8-20.9)	12.9 (9.4-17.4)	0.4990
Moderate poverty	70.6 (63.1-77.0)	13.2 (9.0-18.8)	16.3 (11.2-23.1)	
Low poverty	63.8 (58.3-69.0)	19.7 (15.6-24.5)	16.5 (12.7-21.1)	
Dentist: Population ratio				
Low	69.8 (62.8-75.9)	13.3 (9.4-18.5)	17.0 (12.0-23.3)	0.0530
Moderate	72.3 (66.1-77.7)	15.7 (11.6-20.9)	12.1 (8.4-17.0)	
High	61.8 (55.7-67.7)	20.5 (16.0-25.9)	17.7 (13.4-22.9)	
HAI				
Low	72.1 (65.5-77.8)	13.5 (9.7-18.5)	14.5 (10.1-20.2)	0.2400
Moderate	68.1 (61.7-73.9)	16.5 (12.3-21.8)	15.4 (11.1-20.9)	
High	63.8 (57.8-69.4)	19.2 (14.8-24.5)	17.0 (13.0-21.8)	
GINI				
Low	69.2 (62.6-75.2)	14.8 (10.6-20.2)	16.0 (12.1-21.0)	0.0580
Moderate	70.1 (63.9-75.6)	16.6 (12.5-21.7)	13.2 (9.3-18.5)	
High	68.7 (61.1-75.4)	14.6 (10.3-20.4)	16.7 (11.4-23.8)	
Living Location				
Rural	70.2 (66.0-74.0)	16.5 (13.5-20.1)	13.3 (10.7-16.4)	**0.0270***
Urban	69.8 (62.7-76.0)	14.0 (9.9-19.4)	16.2 (11.4-22.5)	
Bangkok	51.8 (42.2-61.3)	22.0 (15.1-31.1)	26.1 (18.5-35.5)	

5.5.4 Smoking status

Among age group 35-44 years, smoking was associated with sex. Male had distinctly higher proportion of ex-smoker and current smoker compared to Female. Only around 2% of female were ex-smoker and current smoker while 42.2% (95% CI 36.9-47.6) of male were current smoker and 13.8% (95% CI 11.0-17.3) were ex-smoker. At provincial level, smoking was associated with Dentist per population ratio and GINI coefficient. The provinces with high GINI coefficient had the highest proportion of current smoker (25.9; 95% CI 19.8-33.0), followed by low GINI coefficient (21.8% 95% CI 17.3-27.0) and moderate GINI coefficient (14.5%; 11.0-19.0).

Among age group 60-74 years, smoking was also associated with age and sex. Age group 60-64 years had the highest proportion of current smoker (17.7%; 95% CI 13.3-23.2), followed by age group 65-69 years (14.9%; 95% CI 10.9-20.0) and age group 70-74 years (11.2%; 95% cl6.8-17.4). Similar to age group 35-44 years, female was rarely to be ex- and current smoker. Only around 3.5% of female were ex-smoker and current smoker while 28.4% (95% CI 23.4-33.9) of male were current smoker and 22.5% (95% CI18.0-28.8) were ex-smoker. Smoking was not significantly associated with any provincial characteristic measure, but smoking was associated with urban/rural. Proportions of ex-smoker and current smoker were the highest in rural area (13.5%; 95% CI 10.8-16.7, 20.7%; 95% CI 17.2-24.7), followed by urban area (10.8%; 95% CI 7.1-16.2, 10.9%; 95% CI 7.1-16.2) and Bangkok had the lowest proportion (9.3; 95% CI 4.9-17.0; 6.4%; 95% CI 3.1-12.9).

Although smoking was not significantly associated with education and income for both age group, Figure 5-16 shows that individuals who had high education and income less likely to be current smoker. According to area-level factors, individual who lived in the richest area or Bangkok area were less likely to be current smoker.

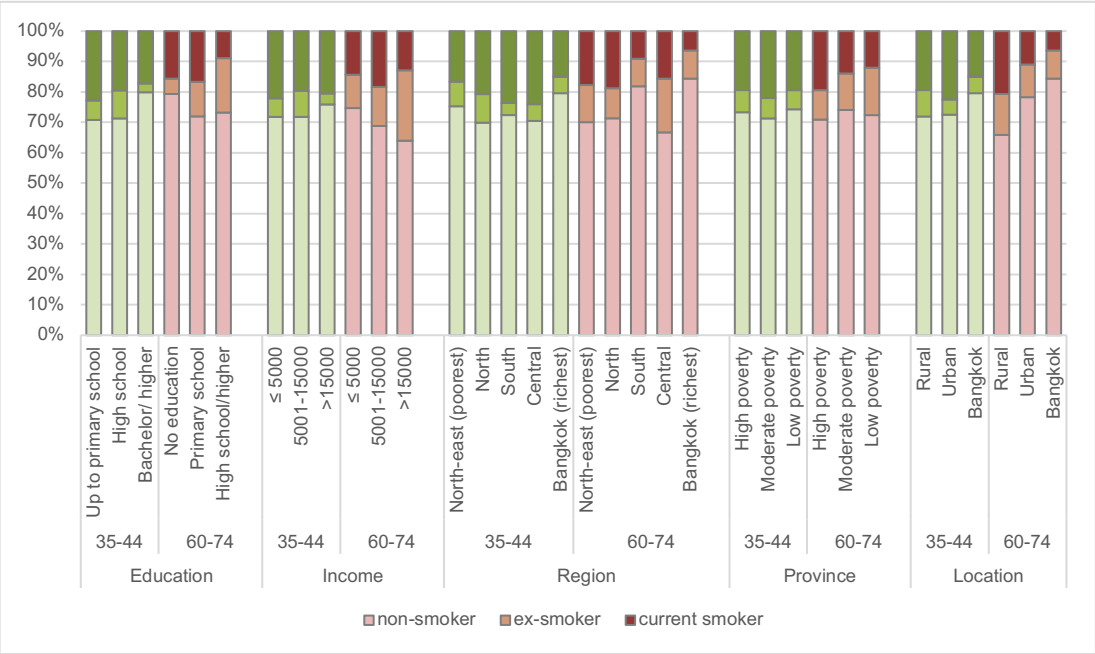

Figure 5-16 Proportion of smoking status by education, income, regions, provincial Poverty Headcount Ratio and type of location.

Table 5-14 The associations between oral health-related outcomes and both individual- and area-level characteristics among 35-44-year-old adults (n = 1,517).

Variables	Smoking Status			
	Non-smoker	Ex-smoker	Current smoker	
	% (95% CI)	% (95% CI)	% (95% CI)	p-value
Age group (years)				
35-39	69.2 (64.1-73.9)	7.0 (5.2-9.4)	23.8 (19.4-28.9)	0.0959
40-45	75.6 (71.0-79.6)	6.7 (4.7-9.3)	17.8 (14.2-22.1)	
Sex				
Male	44.0 (38.8-49.3)	13.8 (11.0-17.3)	42.2 (36.9-47.6)	**<0.001**
Female	98.1 (96.3-99.0)	0.6 (0.2-1.3)	1.4 (0.6-3.2)	***
Education				
Up to primary school	70.8 (66.1-75.0)	6.4 (4.5-9.1)	22.8 (18.9-27.3)	0.0987
High school	71.3 (65.6-76.5)	9.2 (6.6-12.6)	19.5 (14.9-25.2)	
Bachelor/higher	79.9 (69.6-87.3)	2.9 (1.7-5.1)	17.2 (10.1-27.8)	
Income (THB)				
0-5000	71.8(66.6-76.4)	6.1 (4.2-8.7)	22.1 (17.8-27.2)	0.2565
5001-15000	71.8 (66.6-76.5)	8.6 (6.3-11.8)	19.6 (15.4-24.5)	
>15000	75.9 (66.6-83.2)	3.6 (2.1-6.0)	20.5 (13.5-30.0)	
Regions				
North-eastern	75.3 (71.1-79.1)	8.1 (5.8-11.0)	16.6 (13.5-20.3)	0.1928
North	69.9 (62.3-76.6)	9.4 (5.7-15.0)	20.7 (15.1-27.8)	
South	72.4 (61.8-80.9)	4.0 (2.3-7.0)	23.6 (15.4-34.5)	
Central	70.4 (63.4-76.6)	5.5 (3.2-9.4)	24.0 (18.3-30.9)	
Bangkok	79.6 (71.6-85.8)	5.4 (2.4-12.0)	15.0 (10.0-22.1)	
Provincial Poverty Headcount Ratio				
High poverty	73.4 (68.7-77.6)	7.3 (5.2-10.2)	19.4 (15.6-23.7)	0.8261
Moderate poverty	71.3 (65.1-76.8)	6.7 (4.5-9.9)	22.0 (16.9-28.2)	
Low poverty	74.3 (69.9-78.2)	6.3 (4.6-8.7)	19.4 (15.9-23.6)	
Dentist:Population ratio				
Low	73.9 (69.0-78.3)	9.6 (6.8-13.3)	16.5 (13.1-20.7)	**0.0271**
Moderate	71.6 (66.2-76.4)	5.3 (3.5-8.0)	23.1 (18.6-28.4)	*
High	74.0 (69.3-78.1)	8.2 (6.0-11.2)	17.8 (14.2-22.2)	
HAI				
Low	72.1 (66.3-77.2)	5.8 (4.1-8.1)	22.2 (17.3-28.0)	0.5248
Moderate	73.9 (68.8-78.5)	7.6 (5.0-11.4)	18.5 (14.6-23.1)	
High	71.3 (65.9-76.2)	8.2 (5.7-11.8)	20.5 (16.2-25.6)	
GINI				
Low	72.7 (67.3-77.5)	5.6 (3.7-8.5)	21.8 (17.3-27.0)	**0.0046**
Moderate	76.1 (70.9-80.6)	9.4 (6.6-13.3)	14.5 (11.0-19.0)	**
High	68.9 (61.9-75.2)	5.2 (3.6-7.5)	25.9 (19.8-33.0)	
Living Location				
Rural	72.0 (68.6-75.1)	8.7 (6.8-10.9)	19.4 (16.6-22.4)	0.1160
Urban	72.6 (66.1-78.2)	5.0 (3.0-8.1)	22.5 (17.1-28.8)	
Bangkok	79.6 (71.6-85.8)	5.4 (2.4-12.0)	15.0 (10.0-22.1)	

Table 5-15 The associations between oral health-related outcomes and both individual- and area-level characteristics among 60-74-year-old adults (n=1,143).

Variables	Smoking Status			
	Non-smoker	Ex-smoker	Current smoker	
	% (95% CI)	% (95% CI)	% (95% CI)	p-value
Age group (years)				
60-64	72.0 (66.2-77.2)	10.3 (7.5-13.9)	17.7 (13.3-23.2)	**0.0041**
65-69	76.4 (70.5-81.5)	8.7 (5.9-12.8)	14.9 (10.9-20.0)	**
70-74	67.5 (58.0-75.8)	21.3 (14.1-31.1)	11.2 (6.8-17.4)	
Sex				
Male	49.1 (43.1-55.2)	22.5 (18.0-28.8)	28.4 (23.4-33.9)	**<0.001**
Female	96.5 (94.5-97.7)	1.4 (0.7-2.6)	2.2 (1.2-3.9)	***
Education				
No education	79.4 (67.8-87.5)	5.0 (1.9-12.4)	15.6 (8.6-26.7)	0.0689
primary school	72.0 (67.7-75.8)	11.4 (8.9-14.4)	16.7 (13.5-30.4)	
High school/higher	73.3 (61.4-82.5)	18.0 (10.3-29.4)	8.8 (4.4-16.7)	
Income (THB)				
0-5000	74.8 (70.4-78.8)	10.8 (8.0-14.3)	14.4 (11.5-17.9)	0.1403
5001-15000	68.8 (60.0-76.4)	12.9 (8.7-18.7)	18.3 (12.2-26.5)	
>15000	64.0 (49.5-76.3)	23.1 (12.3-39.3)	12.9 (6.8-23.2)	
Regions				
North-eastern	70.0 (63.5-75.8)	12.3 (8.6-17.2)	17.7 (13.1-23.5)	0.0595
North	71.3 (63.5-78.0)	9.9 (6.1-15.8)	18.8 (13.2-26.0)	
South	81.8 (72.0-88.8)	9.0 (4.2-18.4)	9.1 (4.9-16.3)	
Central	66.6 (58.1-74.1)	17.8 (12.3-25.1)	15.6 (10.2-23.0)	
Bangkok	84.3 (75.8-90.2)	9.3 (4.9-17.0)	6.4 (3.1-12.9)	
Provincial poverty				
High poverty	70.9 (64.9-76.3)	9.8 (6.7-14.1)	19.3 (14.8-24.7)	0.1683
Moderate poverty	74.1 (67.2-80.0)	12.0 (8.1-17.6)	13.9 (9.6-19.6)	
Low poverty	72.4 (67.0-77.4)	15.5 (11.5-20.5)	12.1 (8.9-16.1)	
Dentist: Population				
Low	75.2 (69.1-80.5)	10.8 (7.3-15.8)	14.0 (10.2-18.8)	0.1745
Moderate	69.0 (62.5-74.9)	12.1 (8.5-17.0)	18.9 (14.1-24.8)	
High	74.6 (68.5-79.9)	14.8 (10.4-20.6)	10.6 (7.5-14.9)	
HAI				
Low	74.9 (68.8-80.2)	10.4 (7.0-15.3)	14.7 (10.8-19.6)	0.2805
Moderate	68.7 (62.3-74.4)	13.3 (9.5-18.3)	18.0 (13.5-23.7)	
High	74.6 (69.0-79.4)	14.1 (10.4-18.9)	11.3 (8.1-15.6)	
GINI				
Low	69.4 (61.8-76.1)	16.4 (11.5-22.9)	14.2 (9.4-20.9)	0.4806
Moderate	73.2 (67.1-78.5)	10.5 (7.2-15.0)	16.3 (12.0-21.8)	
High	74.2 (67.6-80.0)	10.9 (7.1-16.3)	14.9 (10.9-20.1)	
Living Location				
Rural	65.8 (61.5-70.0)	13.5 (10.8-16.7)	20.7 (17.2-24.7)	**0.0019**
Urban	78.3 (71.8-83.7)	10.8 (7.1-16.2)	10.9 (7.1-16.2)	**
Bangkok	84.3 (75.8-90.2)	9.3 (4.9-17.0)	6.4 (3.1-12.9)	

5.6 Summary of key findings

Socio-economic gradients in oral health status

Regarding individual-level socio-economic position, there were reversed socio-economic gradient in DMFT, which was caused by the reversed gradient in filled teeth while there were ordinary socio-economic gradients in decayed teeth. The pattern of the gradients was similar for both age groups. The socio-economic gradients were also found for periodontal disease and tooth loss, although, no significant association was found.

Regarding area-level socio-economic position, although their results did not show regional and provincial poverty gradient for most outcomes. The results showed statistically significant associations between oral health outcomes and area-level characteristics.

Socio-economic gradients in oral health-related behaviours

Although the results showed inconsistent associations between oral health-related behaviours and socio-economic position, there were some similar pattern of the association that could be summarised. The higher prevalence of adults who brushed their teeth twice daily, visited dentist more than one time during the past and the lower prevalence of current smokers were found among adults who belonged to higher socio-economic group and lived in more privileged area. In contrast, adults who belonged to lower socio-economic group and lived in more deprived area were more likely to used fluoridated toothpaste.

Table 5-16 Summary - the associations between oral health outcomes, oral health-related behaviours, and socio-economic measures

	Education		Income		Regional		Provincial	
	35-44	60-74	35-44	60-74	35-44	60-74	35-44	60-74
Oral health outcome								
DMFT	(+)*	N/A	(+)*	N/A	(x)*	N/A	(x)*	N/A
Decayed	(-)*	(-)*	(-)*	$(x)^{NS}$	(x)*	$(x)^{NS}$	(x)*	$(-)^{NS}$
Filled teeth	(+)*	(+)*	(+)*	(+)*	(+)*	(+)*	(x)*	(+)*
Deep pocket	(-)*	$(x)^{NS}$	$(-)^{NS}$	(x)*	(x)*	(x)*	$(-)^{NS}$	(-)*
Non-functional dentition	$(-)^{NS}$	(x)*	$(-)^{NS}$	$(-)^{NS}$	(x)*	(x)*	(x)*	(x)*
Edentulous	N/A	$(-)^{NS}$	N/A	$(-)^{NS}$	N/A	(+)*	N/A	$(x)^{NS}$
Oral health-related behaviours								
Brushing at least twice a day	(+)*	(x)*	(+)*	$(x)^{NS}$	$(+)^{NS}$	(+)*	$(+)^{NS}$	(+)*
Using of fluoride toothpaste	(-)*	$(+)^{NS}$	(x)*	$(-)^{NS}$	(-)*	$(x)^{NS}$	$(-)^{NS}$	$(x)^{NS}$
Dental visit during the past year	(+)*	(+)*	(+)*	(+)*	(x)*	(x)*	(x)*	$(+)^{NS}$
Smoking status	$(-)^{NS}$	$(x)^{NS}$	$(x)^{NS}$	$(+)^{NS}$	$(x)^{NS}$	$(x)^{NS}$	$(x)^{NS}$	$(x)^{NS}$

(+)=positive gradient
(-) =negative gradient
(x)=no gradient
* =Significant associaton
^{NS} =non-significant association
N/A=Not applicable

Chapter 6 Oral health inequalities: single level model

6.1 Introduction

This chapter reports first stage results from regression analyses, showing the education and income gradients in oral health status at the individual level (addressing objective 1). Three types of regression models were used in this chapter. Firstly, negative binomial models were used for DMFT and the number of decayed teeth. Secondly, zero-inflated negative binomial (ZINB) models were used for the number of filled teeth. Lastly, logistic regression was used for having deep periodontal pockets, having non-functional dentition and for edentulousness. For each outcome, two models were estimated; the unadjusted model (null model) and a model adjusted for age and sex. Education and income were used in separate models.

6.2 Social gradient in dental caries

Negative binomial regression model predicted incident rate ratio of DMFT and the number of decayed teeth. When the result showed incident rate ratio less than one, it indicated that the lower DMFT and number of decayed teeth was found among that group compared to the reference group. On the contrary, when the result showed incident rate ratio more than one, it indicated that the higher DMFT and number of decayed teeth was found among that group. Zero-inflated negative binomial predicted both odds ratio of having no filling and incident rate ratio of the number of filled teeth, which predicted only among who had filled teeth.

6.2.1 Outcome: DMFT

Table 6-1 shows the results of negative binomial regressions predicting the incident rate ratio for the number of decayed, missing and filled teeth (DMFT) among 35-44-year-old adults.

Education gradient

The results showed that higher numbers of DMFT were associated with higher education. Compared to individuals in the lowest education group, those who finished high school and those who had a bachelor degree or higher had 1.03 (95% CI 0.89-1.19) and 1.45 (95% CI 1.26-1.68) times higher DMFT respectively. After adjusting for age and sex, the incident rate ratios were slightly increased to 1.07 (95% CI 0.92-1.21) and 1.50 (95% CI 1.28-1.70), showing that the differences between the lowest and highest education groups were significant but not those between the lowest and the middle education groups (Table 6-1). Figure 6-1 shows the reverse education gradient in DMFT

Income gradient

From the unadjusted model, the analysis showed that higher DMFT was associated with higher income. Compared with individuals in the low income group (0-5,000 THB), those in the middle (5,001-15,000 THB) and high (>15,000 THB) income groups had respectively 1.25 (95% CI 1.07-1.46) and 1.43 (95% CI 1.20-1.70) times significantly higher DMFT. After adjusting for age and sex, the respective incident rate ratios were 1.28 (95% CI 1.11-1.49) for the middle-income group and 1.50 (95% CI 1.27-1.79) for the highest income group. In addition, females had significantly higher DMFT compared to males (IRR=1.32, 95% CI 1.18-1.48) (Table 6-1). The clear reverse income gradient in DMFT is shown in Figure 6-1.

Table 6-1 Results of negative binomial regression models predicting incident rate ratio for the DMFT among 35-44-year-old adults (n = 1,517).

Variables	DMFT			
	Unadjusted	Adjusted	Unadjusted	Adjusted
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Education				
Up to primary	1	1		
High school	1.03 (0.89-1.19)	1.07 (0.93-1.22)		
Bachelor/higher	1.45 (1.26-1.68)***	1.50 (1.30-1.73)***		
Income (THB)				
0-5000			1	1
5001-15000			1.25 (1.07-1.46)**	1.29 (1.11-1.48)**
>15000			1.43 (1.20-1.70)***	1.50 (1.27-1.78)***
Age		1.03 (1.01-1.05)**		1.02 (1.00-1.05)
Sex				
Male		1		1
Female		1.26 (1.12-1.41)***		1.32 (1.18-1.48)***

p-value: ***p<0.001; **p<0.01; *<0.05

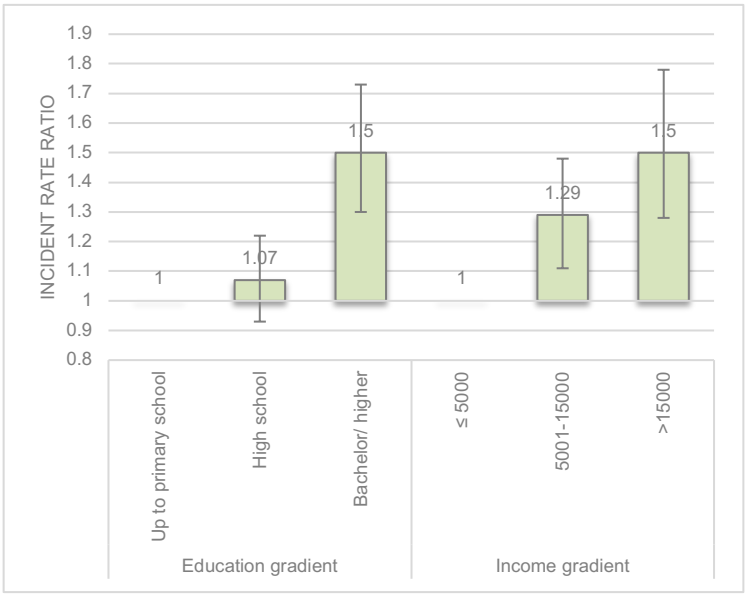

Figure 6-1 Adjusted incident rate ratios for the number of decayed-missing-filled teeth by education and income groups among adults aged 35-44 years

6.2.2 Outcome: Number of decayed teeth

Table 6-2 and Table 6-3 show the results of the negative binomial regression models predicting the incident rate ratio for the number of decayed teeth (DT) among 35-44 and 60-74-year-old adults.

Education gradient

For the 35-44 years age group, the analyses showed that lower numbers of decayed teeth were statistically significant associated with higher education level. Compared to those in the low education group, individuals who finished high school had 32% (IRR=0.68; 95%CI 0.52-0.89) fewer decayed teeth, and those who were educated to bachelor degree or higher had 59% (IRR=0.41; 95%CI 0.27-0.63) fewer decayed teeth. After adjusting for age, sex, there was hardly any change in the estimates.

Among those aged 60-74 years, the results also showed that higher education was associated with lower numbers of decayed teeth. However, significant difference was found only between individuals with no formal education and those who had a bachelor degree or higher. After controlling for age and sex, individuals with a bachelor degree or higher had 46% (IRR=0.54; 95%CI 0.31-0.94) fewer decayed teeth compared to those with no education. This is the only significant difference for this set of models. The education gradients are also graphically presented in Figure 6-2.

Income gradient

Among age group 35-44 years, individuals who belonged to the middle and high-income group had 0.78 (95% CI 0.60-1.03) and 0.50 (95% CI 0.36-0.71) times lower number of decayed teeth compared to those who belonged to the low-income group. After adjusting for age and sex, the incident rate ratio were slightly increased to 0.80

(95% CI 0.61-1.04) and 0.53 (95% CI 0.38-0.75), showing that the differences between the lowest and the highest income groups was statistically significant but not those between the lowest and the middle-income groups (Table 6-2). However, income gradient in number of decayed teeth still existed and was shown in Figure 6-2.

Among the 60-74-year-olds, there was no significant association (and no gradient) between income and the number of decayed teeth in both the unadjusted and age-sex adjusted models. The results of the adjusted models are summarised in a graph (Figure 6-2).

Table 6-2 Results of negative binomial regression models predicting incident rate ratio of the number of decayed teeth (DT) among 35-44-year-old adults (n = 1,517).

Variables	Number of decayed teeth			
	Unadjusted	Adjusted	Unadjusted	Adjusted
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Education				
Up to primary	1	1		
High school	0.68 (0.52-0.89)**	0.66 (0.51-0.86)**		
Bachelor/higher	0.41 (0.27-0.63)***	0.40 (0.26-0.60)***		
Income				
0-5000			1	1
5001-15000			0.78 (0.60-1.03)	0.80 (0.61-1.04)
>15000			0.50 (0.36-0.71)***	0.53 (0.38-0.75)***
Age		0.95 (0.91-1.00)*		0.97 (0.93-1.01)
Sex				
Male		1		1
Female		1.26 (0.99-1.60)		1.16 (0.91-1.48)

p-value: ***p<0.001; **p<0.01; *<0.05

Table 6-3 Results of negative binomial regression models predicting incident rate ratio of the number of decayed teeth (DT) among 60-74-year-old adults (n=1,143).

Variables	Number of decayed teeth			
	Unadjusted	Adjusted	Unadjusted	Adjusted
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
Education				
No education	1	1		
Primary school	0.75 (0.54-1.05)	0.75 (0.53-1.06)		
High school/higher	0.55 (0.32-0.95)*	0.54 (0.31-0.94)*		
Income				
0-5000			1	1
5001-15000			1.04 (0.76-1.42)	1.07 (0.77-1.49)
>15000			0.93 (0.60-1.47)	0.91 (0.59-1.41)
Age		1.02 (0.99-1.05)		1.03 (1.00-1.06)
Sex				
Male		1		1
Female		0.85 (0.66-1.10)		0.90 (0.70-1.16)

p-value: ***p<0.001; **p<0.01; *<0.05

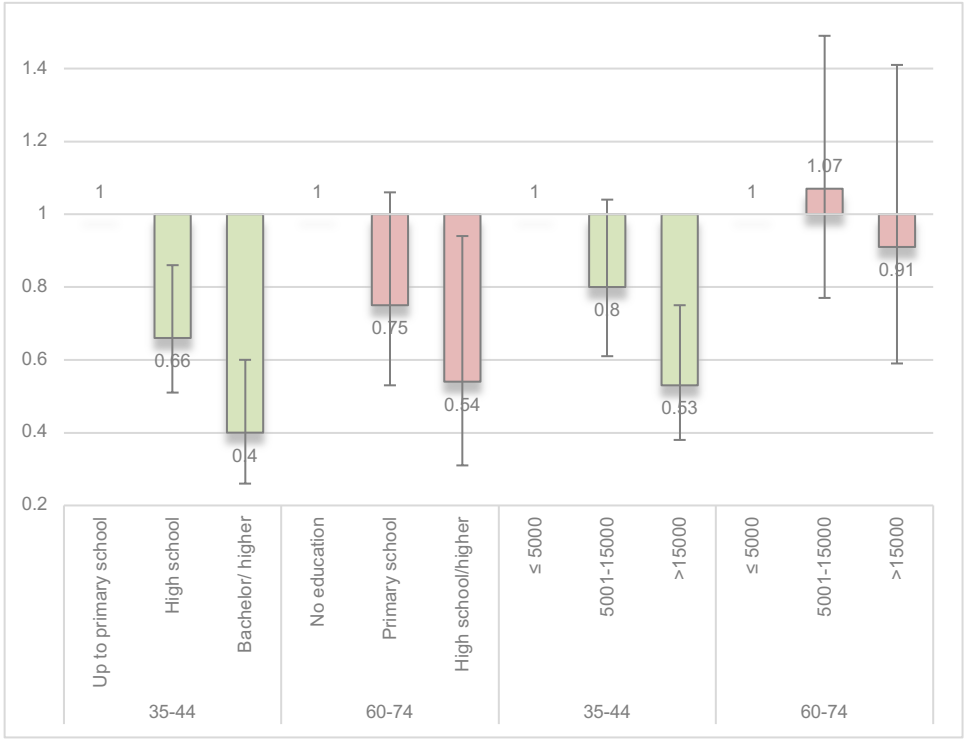

Figure 6-2 Adjusted incident rate ratios for the number of decayed teeth by education and income groups among adults aged 35-44 years and 60-74 years.

6.2.3 Outcome: Number of filled teeth

Table 6-4 and Table 6-5 show the results of the zero-inflated negative binomial regression models for number of filled teeth. The results are divided into two parts: the zero-inflated part, predicting odds ratio for having no filled teeth, and the negative binomial part, predicting incident rate ratio for the number of filled teeth among those with fillings.

Education gradient

Zero-inflated part: predicting odds ratio for having no filled teeth

Among the 35-44 years age group, the unadjusted model showed statistical significant reverse education gradient in having no filled teeth, with higher education groups being associated with lower odds of having no filled teeth. Compared to individuals with primary education, the odds ratio for having no filled teeth was 0.56 (95% CI 0.37-0.84) among those who finished high school and 0.05 (95% CI 0.02-0.15) among those with a bachelor degree. After controlling for age and sex, odds ratio were slightly attenuated, but the gradient still persisted and both estimates remained statistically significant (Table 6-4).

Similarly, among those aged 60-74 years, individuals with higher education were also associated with lower odds of having no filled teeth. Compared to individuals who had no formal education, the odds ratio of having no filled teeth were 0.15 (95% CI 0.03-0.69) among those with primary education and 0.04 (95% CI 0.01-0.23) among those who finished high school or higher. After adjusting for age and sex, the estimates hardly changed (Table 6-5).

Negative binomial part: predicting incident rate ratio for the number of filled teeth

Among age group 35-44 years, high education was associated with high number of filled teeth. Compared to individuals in the lowest education group, those who finished high school and those who had bachelor's degree or higher had 1.37 (95% CI 0.98-1.91) and 1.82 (95% CI 1.34-2.46) times higher number of filled teeth, showing that the differences between the lowest and the highest education groups were significant but not those between the lowest and the middle education groups. After adjusting for age and sex, there was hardly any change in the estimates (Table 6-4).

Among age group 60-74 years, the number of filled teeth was also higher at each higher level of education. Compared to those who had no education, individuals who finished primary school and high school had 1.28 (95% CI 0.42-3.88) and 2.28 (95% CI 0.76-6.88) times higher number of filled teeth, showing that there was no statistically significant difference in the number of filled teeth between each group. After adjusting for age and sex, the estimates hardly changed (Table 6-5).

The results of the adjusted model were summarised in Figure 6-3. The graph shows reverse education gradient in the number of filled teeth. Adults with higher education were more likely to have higher number of filled teeth.

Income gradient

Zero-inflated part: predicting odds ratio for having no filled teeth

Among those aged 35-44 years, the results showed a reverse income gradient in having no filled teeth. Odds ratio of having no filled teeth were lower at each higher level of income. In the unadjusted model, the odds ratio of having no filled teeth were 0.44 (95% CI 0.30-0.66) among individuals with middle income and 0.11 (95% CI 0.06-0.23) among individuals with high income compared to those with low income.

After adjusting for age and sex, the respective odds slightly decreased, and the association remained statistically significant (Table 6-4).

Likewise, among age group 60-74 years, individuals with middle and high income were less likely to have no filled teeth compared to those with low income. The unadjusted model showed that individuals who had middle and high income were 63% (OR=0.37, 95%CI 0.15-0.92) and 60% (OR=0.40 95%CI 0.19-0.85) less likely to have no filled teeth. After controlling for age and sex, the odds ratio of having no filled teeth were even lower and the association was again significant (Table 6-5).

Negative binomial part: predicting incident rate ratio for the number of filled teeth

Among 35-44-year-olds, there was an income gradient in the number of filled teeth, with more filled teeth for participants at each higher level of personal monthly income. Individuals with middle and high income had 1.25 (95% CI 0.94-1.65) and 1.59 (95% CI 1.17-2.16) times more filled teeth compared to those with low income. After adjusting for age and sex, incident rate ratios were 1.26 (95% CI 0.94-1.65) for the middle-income group and 1.68 (95% CI 1.24-2.28) for high-income group, showing that only the differences between the lowest and the highest income groups were statistically significant (Table 6-4).

Similar to the younger age group, adults aged 60-74 years who had high income had more filled teeth compare to those with low income (IRR=1.95; 95% CI 1.11-3.73). However, there were no differences in the number of filled teeth between those in middle and those in low income. Overall, the association between income and number of filled teeth among those with fillings did not show a gradient pattern in this age group. After controlling for age and sex, participants in the high-income group had 1.96 (95% CI 1.12-3.42) times more filled teeth than those in low income (Table 6-5).

The results of adjusted models were summarised in Figure 6-3. It shows reverse income gradient in filled teeth only for age group 35-44 years. Individuals who had high income were more likely to have higher number of filled teeth.

Table 6-4 Results of zero-inflated negative binomial regression models predicting odds of having no filled teeth and incident rate ratios for the number of filled teeth (FT) among 35-44-year-old adults (n=1,517).

	Filled teeth			
	Unadjusted	Adjusted	Unadjusted	Adjusted
Zero-inflated	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Education				
Up to primary	1	1		
High school	0.56 (0.37-0.84)**	0.51 (0.33-0.80)**		
Bachelor/higher	0.05 (0.02-0.15)***	0.05 (0.02-0.13)***		
Income				
0-5000			1	1
5001-15000			0.44 (0.30-0.66)***	0.39 (0.25-0.59)***
>15000			0.11 (0.06-0.23)***	0.09 (0.04-0.17)***
Age		1.02 (0.95-1.10)		1.07 (0.99-1.16)
Sex				
Male		1		1
Female		0.48 (0.31-0.73)**		0.38 (0.25-0.58)***
Negative binomial	**IRR (95% CI)**	**IRR (95% CI)**	**IRR (95% CI)**	**IRR (95% CI)**
Education				
Up to primary	1	1		
High school	1.37 (0.98-1.91)	1.38 (1.00-1.92)		
Bachelor/higher	1.82 (1.34-2.46)***	1.85 (1.39-2.48)***		
Income				
0-5000			1	1
5001-15000			1.25 (0.94-1.65)	1.26 (0.96-1.66)
>15000			1.59 (1.17-2.16)**	1.68 (1.24-2.28)**
Age		1.01 (0.96-1.06)		1.00 (0.95-1.04)
Sex				
Male		1		1
Female		1.09 (0.85-1.41)		1.15 (0.90-1.49)

p-value: ***p<0.001; **p<0.01; *<0.05

Table 6-5 Results of zero-inflated negative binomial regression models predicting odds of having no filled and incident rate ratio for the number of filled teeth (FT) among 60-74-year-old adults (n=1,143).

	Filled teeth			
	Unadjusted	Adjusted	Unadjusted	Adjusted
Zero-inflated	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Education				
No education	1	1		
Primary school	0.15 (0.03-0.69)*	0.13 (0.03-0.65)*		
High school/higher	0.04 (0.01-0.23)***	0.03 (0.01-0.16)***		
Income				
0-5000			1	1
5001-15000			0.37 (0.15-0.92)*	0.32 (0.14-0.76)*
>15000			0.40 (0.19-0.85)*	0.31 (0.14-0.69)**
Age		1.04 (0.94-1.15)		1.01 (0.91-1.11)
Sex				
Male		1		1
Female		0.34 (0.16-0.73)**		0.39 (0.20-0.78)**
Negative binomial	**IRR (95% CI)**	**IRR (95% CI)**	**IRR (95% CI)**	**IRR (95% CI)**
Education				
No education	1	1		
Primary school	1.28 (0.42-3.88)	1.30 (0.41-4.11)		
High school/higher	2.28 (0.76-6.88)	2.36 (0.76-7.37)		
Income				
0-5000			1	1
5001-15000			0.63 (0.37-1.08)	0.62 (0.37-1.03)
>15000			1.95 (1.11-3.73)*	1.96 (1.12-3.42)*
Age		1.00 (0.94-1.07)		0.98 (0.91-1.05)
Sex				
Male		1		1
Female		1.05 (0.62-1.77)		0.95 (0.59-1.54)

p-value: ***p<0.001; **p<0.01; *<0.05

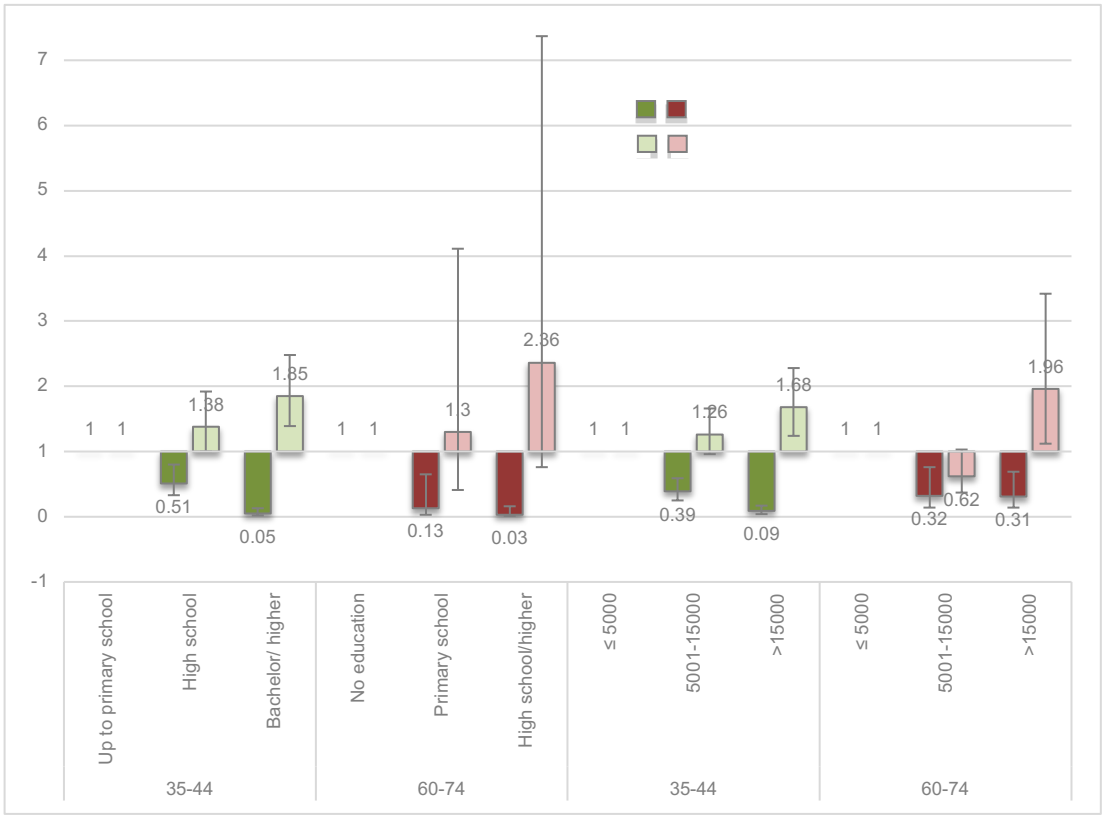

Figure 6-3 Adjusted odds ratios for having no filled teeth and adjusted incident rate ratios for the number of filled teeth by education and income groups among participants aged 35-44 years and 60-74 years.

6.3 Social gradients in periodontal disease

Table 6-6 and Table 6-7 show the results of logistic regression predicting the odds ratio for periodontal diseases, defined by having a deep periodontal pocket (≥6 mm.) among 35-44 and 60-74-year-old adults.

Education gradient

For the 35-44 years age group, the analyses showed that the highest education group was less likely to have deep periodontal pocket. After adjusting for age and sex, compared to individuals in the lowest education group, those who finished high school were 31% (OR=0.69; 95% CI 0.29-1.66) less likely to have deep periodontal pocket, and those with bachelor's degree or higher were 59% (OR=0.41; 95% CI 0.17-0.98) less likely to have deep periodontal pocket. A significant difference was found only between the lowest and highest education groups (Table 6-6).

Similarly, among those aged 60-74 years, individuals with higher education were less likely to have deep periodontal pocket. Compared to individuals in the lowest education group, those who finished primary school were 16% (OR=0.84; 95% CI 0.38-1.87) less likely to have deep periodontal pocket and those who finished high school or higher were 41% (OR=0.59; 95% CI 0.18-1.87), showing that there were no significant differences between the lowest, middle and highest education groups (Table 6-7).

The results of the adjusted model are shown in Figure 6-4. The graph shows education gradient in periodontal diseases among both age groups.

Income gradient

Among age group 35-44 years, unadjusted logistic regression model showed that having deep periodontal pocket was not significantly associated with income in both the unadjusted and age-sex adjusted models. After adjusting for age and sex, the odds ratios of having deep periodontal pocket were 0.97 (95% CI 0.47-1.97) among middle-income group and 0.50 (95% CI 0.21-1.18) among high-income group (Table 6-6).

Among age group 60-74 years, using individuals who had low income as the reference category, the results showed that individuals in middle-income group were 1.69 (95% CI 0.97-2.95) times more likely to have deep periodontal pocket while those in high-income group were 0.17 (95% CI 0.05-0.62) times less likely to have a deep periodontal pocket. After controlling for age and sex, the odds of having deep periodontal pocket remained statistically significant only for the high-income group. Compared to the lowest income group, individual in the highest income group were 84% (OR=0.16; 95% CI 0.04-0.57) less likely to have deep periodontal pocket (Table 6-7). The results of adjusted models were also summarized in Figure 6-4.

Table 6-6 Results of logistic regression models predicting odds of having deep periodontal pocket (≥6mm.) among 35-44-year-old adults (n=1,517).

Variables	Having deep periodontal pocket			
	Unadjusted	Adjusted	Unadjusted	Adjusted
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Education				
Up to primary	1	1		
High school	0.68 (0.30-1.54)	0.69 (0.29-1.66)		
Bachelor/higher	0.39 (0.16-0.93)*	0.41 (0.17-0.98)*		
Income				
0-5000			1	1
5001-15000			0.97 (0.48-1.96)	0.97 (0.47-1.97)
>15000			0.52 (0.21-1.24)	0.50 (0.21-1.18)
Age		1.06 (0.97-1.15)		1.07 (0.99-1.17)
Sex				
Male		1		1
Female		0.91 (0.46-1.81)		0.88 (0.47-1.67)

p-value: ***p<0.001; **p<0.01; *<0.05

Table 6-7 Results of logistic regression models predicting odds of having deep periodontal pocket (≥6mm.) among 60-74-year-old adults (n=1,143).

Variables	Having deep periodontal pocket			
	Unadjusted	Adjusted	Unadjusted	Adjusted
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Education				
No education	1	1		
Primary school	1.01 (0.46-2.20)	0.84 (0.38-1.87)		
High school/higher	0.70 (0.22-2.21)	0.59 (0.18-1.87)		
Income				
0-5000			1	1
5001-15000			1.69 (0.97-2.95)	1.53 (0.88-2.67)
>15000			0.17 (0.05-0.62)**	0.16 (0.04-0.57)**
Age		0.94 (0.88-1.00)*		0.95 (0.89-1.00)
Sex				
Male		1		1
Female		0.82 (0.49-1.39)		0.88 (0.54-1.43)

p-value: ***p<0.001; **p<0.01; *<0.05

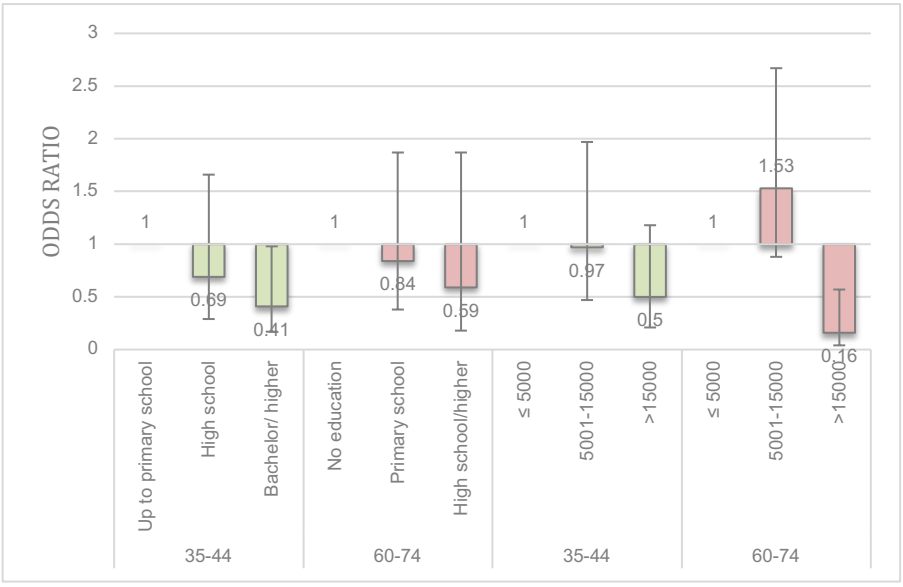

Figure 6-4 Adjusted odds ratios for having deep periodontal pocket by education and income groups among age group 35-44 and 60-74 years.

6.4 Social gradients in tooth loss

6.4.1 Outcome: non-functional dentition

Table 6-8 and Table 6-9 show the results of logistic regression model predicting odds ratios for having less than 20 teeth (non-functional dentition) among 35-44 and 60-74-year-old adults.

Education gradient

Among age group 35-44 years, compared to the lowest education group, individuals who finished high school were 41% (OR=0.59; 95% CI 0.21-1.67) less likely to have less than 20 teeth and those who had bachelor's degree or higher were 78% (OR=0.22; 95% CI 0.06-0.73) less likely to have less than 20 teeth. After adjusted for age and sex, overall odds ratios slightly increased. Compared to the lowest education group, individuals who finished high school and those who had bachelor's degree or higher were 31% (OR=0.69; 95% CI 0.24-1.97) and 74% (OR=0.26; 95% CI 0.07-0.88) less likely to have less than 20 teeth, showing that only the differences between the lowest and the highest education were statistically significant (Table 6-8).

On the other hand, among age group 60-74 years, no significant association between non-functional dentition and education even after adjusted for age and sex. However, the analyses showed that having less than 20 teeth was significantly associated with age (OR=1.08; 95% CI 1.03-1.13) (Table 6-9).

The results of adjusted models were summarized in Figure 6-5. The graph shows education gradient in having non-functional dentition only in age group 35-44 years. Adults with higher education were less likely to have non-functional dentition.

Income gradient

The income gradient in non-functional dentition was found only among age group 35-44 years. After adjusting for age and sex, compared to the lowest income group, individuals with middle-income were 30% (OR=0.70; 95% CI 0.26-1.90) less likely to have less than 20 teeth and those with high-income were 0.11 (95% CI 0.02-0.57) times less likely to have less than 20 teeth. The significant differences were found only between the lowest and the highest income groups. In addition, having less than 20 teeth was also significantly associated with age (OR=1.26; 95% CI 1.02-1.56) (Table 6-8).

In contrast, among age group 60-74 years, having less than 20 teeth was not associated with income in both adjusted and unadjusted models. However, the results showed that having less than 20 teeth was associated with age (OR=1.08; 95% CI 1.03-1.13) (Table 6-9)

The results of adjusted models were summarized in Figure 6-5. The graph shows income gradient in having non-functional dentition only in age group 35-44 years. Adults with higher income were less likely to have non-functional dentition (Figure 6-5)

Table 6-8 Results of logistic regression models predicting odds of having less than 20 teeth (non-functional dentition) among 35-44-year-old adults (n=1,517).

Variables	Non-functional dentition (having less than 20 teeth)			
	Unadjusted	Adjusted	Unadjusted	Adjusted
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Education				
Up to primary	1	1		
High school	0.59 (0.21-1.67)	0.69 (0.24-1.97)		
Bachelor/higher	0.22 (0.06-0.73)*	0.26 (0.07-0.88)*		
Income				
0-5000			1	1
5001-15000			0.65 (0.24-1.78)	0.70 (0.26-1.90)
>15000			0.11 (0.02-0.54)**	0.11 (0.02-0.57)**
Age		1.24 (0.99-1.54)		1.26 (1.02-1.56)*
Sex				
Male		1		1
Female		2.32 (0.95-5.66)		2.11 (0.88-5.06)

p-value: ***p<0.001; **p<0.01; *<0.05

Table 6-9 Results of logistic regression models predicting odds of having less than 20 teeth (non-functional dentition) among 60-74-year-old adults (n=1,143).

Variables	Non-functional dentition (having less than 20 teeth)			
	Unadjusted	Adjusted	Unadjusted	Adjusted
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Education				
No education	1	1		
Primary school	1.25 (0.68-2.30)	1.63 (0.08-3.02)		
High school/higher	1.21 (0.55-2.64)	1.58 (0.71-3.51)		
Income				
0-5000			1	1
5001-15000			0.91 (0.58-1.43)	1.07 (0.67-1.70)
>15000			0.72 (0.38-1.34)	0.81 (0.44-1.49)
Age		1.08 (1.03-1.13)**		1.08 (1.03-1.13)**
Sex				
Male		1		1
Female		1.42 (0.98-2.07)		1.39 (0.96-2.00)

p-value: ***p<0.001; **p<0.01; *<0.05

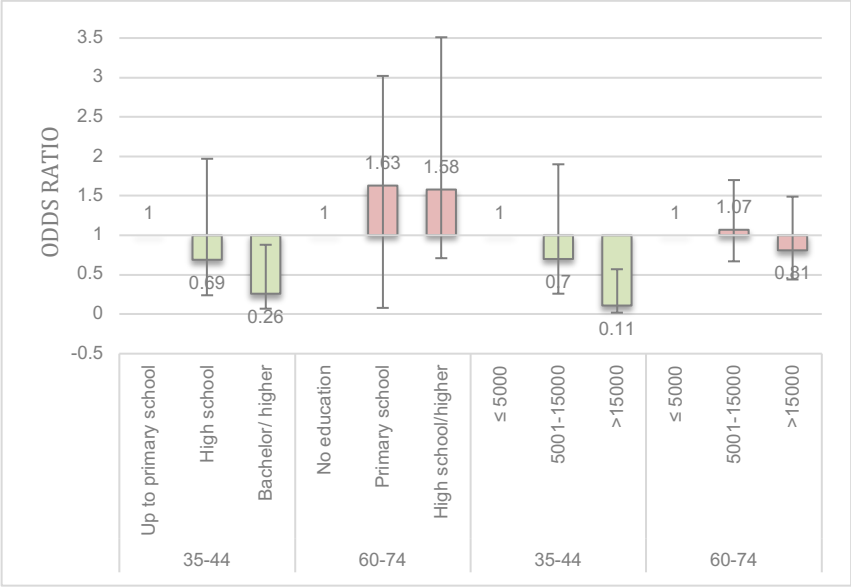

Figure 6-5 Adjusted odds ratios for having non-functional dentition by education and income groups among age group 35-44 and 60-74 years

6.4.2 Outcome: edentulousness

Table 6-10 shows the results of logistic regression models predicting odds ratios for being edentate among 60-74-years-old adults.

Education gradient

The unadjusted model shows that individuals who had high education (i.e. finished high school) were significantly less likely to be edentate compared to those with no formal education (OR= 0.25; 95%CI 0.06-0.97), while there were no differences in edentulousness between those with no education and participants who finished primary school. After controlling for age and sex, the association between edentulousness and education became non-significant. In addition, the results showed that edentulousness was significantly associated with age. For each year increase in age, the odds ratio of being edentulous increased by 1.17 (95% CI 1.08-1.27) times (Table 6-10). The results of the adjusted model were also summarized in Figure 6-6.

Income gradient

The unadjusted model showed that individuals who had high income were less likely to be edentate. Compared to the lowest income group, those with middle income and high income were 0.48 (95% CI 0.21-1.11) and 0.19 (95% CI 0.06-0.68) times less likely to be edentate. After adjusting for age and sex, odds ratios were slightly increased to 0.60 (95% CI 0.25-1.44) for middle-income group and 0.23 (95% CI 0.06-0.83) for high-income group. The significant difference in being edentate was found only between those in the lowest and the highest income group. In addition, the results also showed that edentulousness was associated with age (OR=1.15; 95% CI 1.06-1.26) (Table 6-10).

The results of the adjusted model were summarized in Figure 6-6. The graph shows income gradient in edentulousness.

Table 6-10 Results of logistic regression models predicting odds of being edentulous among 60-74-year-old adults (n=1,264).

Variables	Education gradient		Income gradient	
	Unadjusted	Adjusted	Unadjusted	Adjusted
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Education				
No education	1	1		
Primary school	0.93 (0.28-3.11)	1.44 (0.43-4.81)		
High school/higher	0.25 (0.06-0.97)*	0.36 (0.09-1.43)		
Income				
0-5000			1	1
5001-15000			0.48 (0.21-1.11)	0.60 (0.25-1.44)
>15000			0.19 (0.06-0.68)*	0.23 (0.06-0.83)*
Age		1.17 (1.08-1.27)***		1.15 (1.06-1.26)**
Sex				
Male		1		1
Female		1.19 (0.60-2.38)		1.17 (0.58-2.35)

p-value: ***p<0.001; **p<0.01; *<0.05

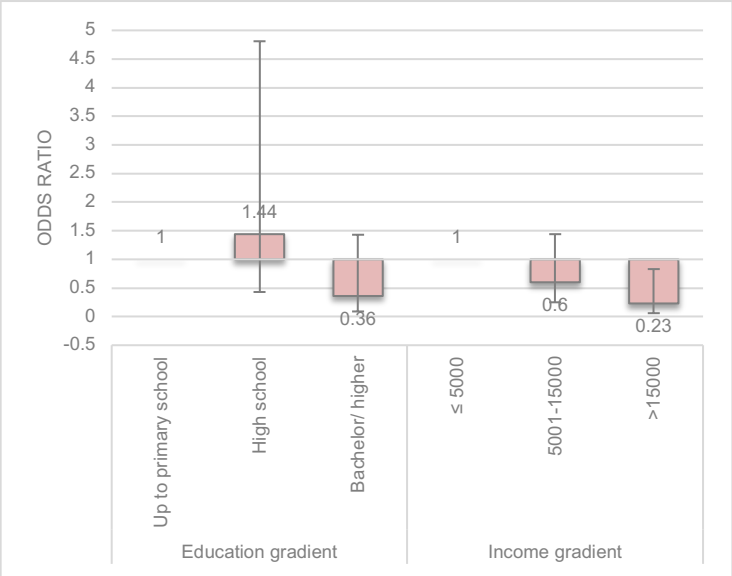

Figure 6-6 Adjusted odds ratios for being edentulous by education and income groups among age group 60-74 years

6.5 Summary of key findings

The association between oral health outcomes and the two individual-level socio-economic factors were summarised in Table 6-11.

Dental caries

The results showed that the higher DMFT was associated with both high education and income. Clear reverse income gradient in DMFT was found among the age group 35-44 years.

The education gradients in decayed teeth were found in both age groups but among the age group 60-74 years the significant difference was found only between the lowest and the highest education groups. There was also some evidence on income gradient in decayed teeth among age group 35-44 years but the significant difference was found only between the lowest and the highest income groups. In contrast, no significant association between decayed teeth and income among age group 60-74 years.

Among individuals who had filled teeth, there was some evidence of reverse education and income gradient in the number of filled teeth among age group 35-44 years. However, the significant difference was found only between the lowest and the highest education and income groups. Among age group 60-74 years, no significant association between education and the number of filled teeth was found. However, the number of filled teeth was associated with income. Compared to the lowest income group, those with high income had a significantly higher number of filled teeth. In addition, the results also showed education and income gradients in having no filled teeth for both age groups. Individuals with high socio-economic position had lower odds of having no filled teeth.

Periodontal diseases

Among age group 35-44 years, the results showed that having deep periodontal pocket was significantly associated with only education and only the differences between the lowest and the highest education groups were statistically significant. In contrast, among age group 60-74 years, having deep periodontal pocket was significantly associated with only income. Only the differences between the lowest and the highest income groups were statistically significant. Individuals with high income were less likely to have a deep periodontal pocket compare to those with low income.

Tooth loss

The results showed education and income gradients in non-functional dentition among age group 35-44 years, however, the significant differences were found only between the lowest and the highest education and income groups. In contrast, among age group 60-74 years, neither education nor income were significantly associated with non-functional dentition.

Moreover, there was income gradient in edentulousness among age group 60-74 years, however, only the differences between the lowest and the highest income groups were statistically significant.

Adjusting for age and sex rarely changed the estimates of the association between oral health outcome and individual-level socio-economic position. Adjusting for age and sex, did some changed in the association between periodontal diseases, tooth loss and socio-economic position only among age group 60-74 years.

Table 6-11 Summary - the associations between oral health outcomes and individual-level socio-economic position.

	Education		Income	
	35-44	**60-74**	**35-44**	**60-74**
DMFT	(+)^{h}	N/A	(+)***	N/A
Decayed teeth	(-)***	(-)^{h}	(-)^{h}	(x)^{NS}
Filled teeth				
No filled teeth	(-)***	(-)***	(-)***	(-)***
Number of filled teeth	(+)^{h}	(+)^{NS}	(+)^{h}	(x)^{h}
Deep periodontal pocket	(-)^{h}	(-)^{NS}	(-)^{NS}	(x)^{h}
Non-functional dentition	(-)^{h}	(x)^{NS}	(-)^{h}	(x)^{NS}
Edentulous	N/A	(x)^{NS}	N/A	(-)^{h}

(+) = positive gradients
(-) = negative gradients
(x)= no gradient
***= clear gradient
^{h} = the significant differences were found only between the lowest and highest socio-economic groups.
^{NS} = non-significant association
N/A=Not applicable

Chapter 7 Results from multilevel analyses

7.1 Introduction

This chapter addresses objective three of the thesis: To examine the relative importance of education and income and examine whether the observed gradients in oral health are fully or partly explained by factors operating at the individual level and area level. It reports the results from the multilevel analyses, which assessed the variation in oral health status between provinces. The 7th Thai National Oral Health Survey recruited individuals from 17 provinces, so that the data was hierarchically structured at two levels: individuals (level 1) nested in provinces (level 2). Two types of multilevel regression were used, depending on the outcome. Multilevel negative binomial regression was used for all dental caries outcomes. Multilevel logistic regression was used for all binary outcomes. For each oral health outcome, a series of seven models was run. The modelling strategy has been described in detail in section 4.5.3.5 and is here briefly summarised as follows:

Model 1: was the null model (including only the outcome variable).
Model 2: adjusted for education.
Model 3: adjusted for income.
Model 4: adjusted for both education and income.
Model 5: Model 4, adjusted additionally for age, sex, and oral health-related behaviours (depending on the outcome).
Model 6: Model 5, adjusted additionally for area characteristics (Poverty Headcount Ratio, Dentist per Population ratio, Human Achievement Index and GINI coefficient).
Model 7: Model 6, adjusted additionally for location type (urban, rural, or Bangkok).

7.2 Dental caries

7.2.1 Outcome: DMFT

Table 7-1 shows results of multilevel negative binomial models predicting the incidence rate ratio (IRR) for the number of decayed, missing and filled teeth (DMFT) among 35-44-year old adults. Model 1, the empty model, indicates that the between-province variance for the DMFT was 0.11, which was statistically significant at 0.001 level, meaning that there was a variation in DMFT between provinces.

After adding education as an explanatory variable (Model 2), the between-province variance did not change substantially and remained statistically significant. Compared to those with primary-level education only, individuals who had a bachelor's degree or higher had a 1.43 (95%CI 1.25-1.64) times higher DMFT. There was no statistically significant difference between those with primary education and those who finished high school. Adding income as an explanatory variable (Model 3) also did not change the between-province variance. Compared to individuals with a lower income, individuals on incomes of more than 15,000 THB had a 1.22 (95%CI 1.06-1.40) times higher DMFT. When both education and income were added into the model (Model 4), the association with income became non-significant while the association with education remained. After further adjusting for age, sex, and oral health behaviours (Model 5), the between-province variance did not change substantially. A one-year increase in age was associated with a 2% increase in DMFT (IRR=1.02; 95%CI 1.00-1.04), while being female was associated with a 33% increase (IRR=1.33; 95%CI 1.21-1.45). Moreover, compared to those who did not visit the dentist during the past year, individuals who attended once had a 1.29 time higher DMFT (95%CI 1.16-1.44),

whereas for those who attended more than once the DMFT was 1.58 (95%CI 1.40-1.80) times higher.

After controlling for area-level characteristics (Model 6), the between-province variance decreased to 0.03 but remained statistically significant at 0.001 level. Living in a province with a higher dentist per population ratio was associated with a higher DMFT (IRR=1.08; 95%CI 1.01-1.16). On the other hand, the Human Achievement Index was negatively associated with DMFT (IRR=0.93 95%CI 0.89-0.98). In the final model, additionally taking type of location into account, the between-province variance remained unchanged and statistically significant. Compared to those who were living in rural areas, adults residing in urban areas had a 1.22 (95%CI 1.11-1.35) times higher DMFT while individuals who were living in Bangkok had a 0.84 (95%CI 0.50-1.43) times lower DMFT. However, the association was statistically significant only for the difference between rural and urban areas.

Table 7-1 Results of multilevel negative binomial regression models predicting incidence rate ratio of DMFT among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
Up to primary		1		1	1	1	1
High school		1.06 (0.96-1.17)		1.05 (0.95-1.17)	1.04 (0.93-1.15)	1.02 (0.92-1.13)	1.00 (0.90-1.11)
Bachelor degree/higher		1.43 (1.25-1.64)***		1.41 (1.21-1.64)***	1.25 (1.08-1.45)**	1.24 (1.07-1.44)**	1.17 (1.01-1.36)*
Income							
5000			1	1	1	1	1
5001-15000			1.07 (0.96-1.19)	1.00 (0.90-1.12)	1.05 (0.95-1.18)	1.06 (0.95-1.18)	1.05 (0.95-1.17)
>15000			1.22 (1.06-1.40)**	1.04 (0.89-1.21)	1.10 (0.95-1.28)	1.11 (0.95-1.28)	1.09 (0.94-1.27)
Age					1.02 (1.00-1.04)*	1.02 (1.00-1.04)*	1.02 (1.00-1.03)*
Female					1.33 (1.21-1.45)***	1.32 (1.21-1.45)***	1.32 (1.21-1.44)***
Dental visit within the past year							
None					1	1	1
1 time					1.29 (1.16-1.44)***	1.30 (1.17-1.44)***	1.30 (1.17-1.44)***
>1 time					1.58 (1.40-1.80)***	1.59 (1.40-1.80)***	1.57 (1.39-1.78)***
Used Fluoride toothpaste							
No					1	1	1
Yes					0.94 (0.85-1.04)	0.94 (0.85-1.04)	0.94 (0.85-1.04)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						0.99 (0.97-1.00)	0.99 (0.98-1.00)
Dentist : 100,000 population[2]						1.08 (1.01-1.16)*	1.10 (1.02-1.19)*
HAI[3]						0.93 (0.89-0.98)**	0.94 (0.89-0.98)*
GINI[4]						0.98 (0.97-1.00)	0.99 (0.97-1.01)
Location type							
Rural							1
Urban							1.22 (1.11-1.35)***
Bangkok							0.84 (0.50-1.43)
Constant	5.67 (4.82-6.66)***	5.24 (4.44-6.17)***	5.29 (4.46-6.26)***	5.21 (4.38-6.19)***	4.01 (3.30-4.88)***	3.90 (3.35-4.55)***	3.75 (3.21-4.39)***
Between province variance	0.11 (0.04)***	0.10 (0.04)***	0.10 (0.04)***	0.10 (0.04)***	0.09 (0.03)***	0.03 (0.01)***	0.03 (0.01)***
Overdispersion parameter	0.62	0.60	0.62	0.60	0.53	0.53	0.52

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

7.2.2 Outcome: Number of decayed teeth

Table 7-2 shows results of multilevel negative binomial regression models predicting the incidence rate ratio for the number of decayed teeth among 35-44-year old adults. Model 1, the empty model, indicates that the between-province variance was 0.26, which was statistically significant at 0.001 level.

After adding education as an explanatory variable (Model 2), the between-province variance slightly increased to 0.29. A higher level of education was strongly associated with lower levels of decay: compared to those with primary-level education, the number of decayed teeth was 0.67 (95%CI 0.54-0.83) times lower for those with high school education and 0.39 (95%CI 0.28-0.54) times lower among those with a bachelor degree. Adding only income as an explanatory variable (Model 3) increased the between-province variance to 0.31. Compared to individuals with a lower income, the middle and high-income groups had 0.75 (95%CI 0.60-0.94) and 0.54 (95%CI 0.40-0.73) times lower number of decayed teeth. In Model 4, controlling for both education and income simultaneously, only the association with education remained significant, and the between-province variance did not change substantially. Additionally controlling for age, sex and oral-related behaviours (Model 5) did not lead to changes in the between-province variance. The results showed no significant associations between a number of decayed teeth and any of the following: age, sex, the number of dental visits during the past year, and use of fluoride toothpaste.

Models 6 and 7 were additionally adjusted for provincial characteristics and location type. The results showed no statistically significant associations between provincial characteristics or location type and the number of decayed teeth, and the between-province variance remained statistically significant.

Table 7-3 shows the results of multilevel negative binomial regression models predicting the incidence rate ratio of the number of decayed teeth among 60-74-year old adults. Model 1 shows a statistically significant between-province variance. Model 2 again shows a statistically significant association between education and the number of decayed teeth among the age group 60-74 years. Compared to no education, those who completed primary school had a 0.71 (95%CI 0.51-0.99) times lower number of decayed teeth, while for those who attended high school or higher the number was 0.52 (95%CI 0.34-0.79) times lower. No associations were found between income and number of decayed teeth. Additionally controlling for age, sex, number of dental visits during the past year and use of fluoride toothpaste (Model 5), the results show a positive association with age: The number of decayed teeth increased by 3% for each year increase in age (IRR=1.03; 95%CI 1.01-1.06). In addition, those who had visited the dentist at least once during the past year had approximately a 25% lower number of decayed teeth compared to those who did not visit the dentist. Further adjusting for provincial characteristics and type of location, the between-province variance slightly decreased but remained statistically significant. Similar to the 35-44 age group, no associations were found between provincial characteristics and number of decayed teeth. Compared to older adults who lived in rural areas, those who lived in urban areas had a 0.73 (95%CI 0.59-0.90) times lower number of decayed teeth (Model 7). There was no statistically significant difference between rural areas and Bangkok.

Table 7-2 Results of multilevel negative binomial regression models predicting incidence rate ratio of decayed teeth among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
Up to primary		1		1	1	1	1
High school		0.67 (0.54-0.83)***		0.69 (0.55-0.85)**	0.67 (0.54-0.84)***	0.66 (0.53-0.82)***	0.68 (0.54-0.85)**
Bachelor degree/higher		0.39 (0.28-0.54)***		0.44 (0.31-0.63)***	0.42 (0.30-0.60)***	0.42 (0.29-0.59)***	0.44 (0.31-0.64)***
Income							
5000			1	1	1	1	1
5001-15000			0.75 (0.60-0.94)*	0.89 (0.71-1.13)	0.90 (0.71-1.14)	0.92 (0.72-1.16)	0.92 (0.73-1.17)
>15000			0.54 (0.40-0.73)***	0.73 (0.52-1.01)	0.75 (0.54-1.05)	0.77 (0.55-1.08)	0.78 (0.55-1.09)
Age					0.98 (0.94-1.01)	0.98 (0.94-1.01)	0.98 (0.94-1.01)
Female					1.06 (0.87-1.29)	1.06 (0.87-1.30)	1.07 (0.88-1.31)
Dental visit within the past year							
None					1	1	1
1 time					0.94 (0.74-1.19)	0.95 (0.75-1.20)	0.95 (0.75-1.20)
>1 time					0.99 (0.74-1.32)	0.99 (0.74-1.32)	1.00 (0.75-1.33)
Used Fluoride toothpaste							
No					1	1	1
Yes					0.86 (0.69-1.07)	0.86 (0.69-1.08)	0.86 (0.69-1.07)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						1.00 (0.97-1.03)	1.00 (0.97-1.03)
Dentist : 100,000 population[2]						1.13 (0.97-1.32)	1.14 (0.97-1.34)
HAI[3]						0.90 (0.81-1.00)	0.91 (0.82-1.02)
GINI[4]						0.96 (0.92-1.00)	0.96 (0.92-1.00)
Location type							
Rural							1
Urban							0.85 (0.67-1.07)
Bangkok							0.84 (0.27-2.60)
Constant	0.76 (0.58-0.99)*	0.97 (0.73-1.30)	0.95 (0.69-1.30)	1.05 (0.76-1.44)	1.16 (0.79-1.70)	1.11 (0.80-1.55)	1.15 (0.82-1.61)
Between province variance	0.26 (0.11)***	0.29 (0.11)***	0.31 (0.12)***	0.30 (0.12)***	0.30 (0.12)***	0.13 (0.06)***	0.12 (0.06)***
Overdispersion parameter	2.28	2.09	2.17	2.07	2.05	2.05	2.04

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table 7-3 Results of multilevel negative binomial regression models predicting incidence rate ratio of decayed teeth among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
No education		1		1	1	1	1
Primary school		0.71 (0.51-0.99)*		0.71 (0.51-0.99)*	0.75 (0.54-1.05)	0.76 (0.54-1.06)	0.79 (0.57-1.11)
High school/higher		0.52 (0.34-0.79)**		0.55 (0.36-0.83)**	0.58 (0.38-0.89)*	0.58 (0.38-0.89)*	0.69 (0.45-1.07)
Income							
5000			1	1	1	1	1
5001-15000			0.99 (0.79-1.24)	1.01 (0.80-1.26)	1.07 (0.85-1.35)	1.07 (0.85-1.34)	1.05 (0.83-1.32)
>15000			0.71 (0.50-1.01)	0.77 (0.54-1.09)	0.81 (0.57-1.15)	0.81 (0.57-1.15)	0.77 (0.54-1.09)
Age					1.03 (1.01-1.06)**	1.03 (1.01-1.05)**	1.03 (1.01-1.06)**
Female					1.01 (0.84-1.22)	1.01 (0.84-1.22)	1.02 (0.85-1.23)
Dental visit within the past year							
None					1	1	1
1 time					0.76 (0.59-0.97)*	0.75 (0.59-0.97)*	0.76 (0.59-0.97)*
>1 time					0.73 (0.57-0.94)*	0.73 (0.56-0.94)*	0.72 (0.56-0.93)*
Used Fluoride toothpaste							
No					1	1	1
Yes					0.93 (0.75-1.15)	0.93 (0.76-1.15)	0.92 (0.74-1.13)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						1.01 (0.98-1.03)	1.01 (0.99-1.03)
Dentist : 100,000 population[2]						1.02 (0.90-1.15)	1.03 (0.90-1.16)
HAI[3]						1.01 (0.93-1.10)	1.02 (0.94-1.11)
GINI[4]						0.99 (0.96-1.03)	0.99 (0.96-1.03)
Location type							
Rural							1
Urban							0.73 (0.59-0.90)**
Bangkok							0.73 (0.31-1.74)
Constant	1.55 (1.30-1.84)***	2.19 (1.55-3.10)***	1.59 (1.33-1.92)***	2.21 (1.56-3.14)***	2.37 (1.57-3.57)***	2.37 (1.58-3.56)***	2.55 (1.69-3.83)***
Between province variance	0.10 (0.05)***	0.08 (0.04)***	0.10 (0.05)***	0.09 (0.04)***	0.07 (0.04)***	0.07 (0.04)***	0.06 (0.03)***
Overdispersion parameter	1.74	1.72	1.73	1.71	1.66	1.66	1.64

***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achieivement Index [4] unit = 1 percent of GINI index

7.2.3 Outcome: Number of filled teeth

Table 7-4 shows results of multilevel negative binomial models predicting the incidence rate ratio for the number of filled teeth among 35-44-year old adults. Model 1, the empty model, indicates that the between-province variance was 0.24, which was statistically significant at 0.001 level.

After adding education as an explanatory variable (Model 2), the between-province variance decreased to 0.16 but remained statistically significant. Higher education level was strongly related to a higher number of filled teeth. Compared to those with only primary education, the number of filled teeth was on average two times higher among individuals who had finished high school (IRR=2.00; 95%CI 1.58-2.53) and 4.60 (95%CI 3.40-6.24) times higher among those with a bachelor's degree. In Model 3 with only income as an explanatory variable, the between-province variance was similar to Model 2 and statistically significant. Compared to individuals with lower incomes, those with incomes of 5000-15,000 THB had a 1.29 (95%CI 1.00-1.67) times higher number of filled teeth, while for those with more than 15,000 THB it was 2.40 (95%CI 1.75-3.29) times higher. When both education and income were added (Model 4), only the association with education remained statistically significant. Further adjusting for age, sex, and oral health behaviours (Model 5) did not change the between-province variance. In Model 5, the association with education was further attenuated, while the association with income became statistically significant for the high-income group (>15,000THB). The number of filled teeth decreased with age (IRR=0.97 95%CI 0.93-1.00) and was higher among women than among men (IRR= 2.33; 95%CI 1.90-2.86). Moreover, individuals who visited the dentist once or more than once during the past year had a 2.07 (95%CI 1.64-2.60) and 2.52 (95%CI 1.92-

3.30) times higher number of filled teeth compared to those who did not visit the dentist.

After controlling for provincial characteristics (Model 6), the between-province variance decreased to 0.01 and became non-significant. Provincial Poverty Index and Human Achievement Index were negatively associated with the number of filled teeth. The number of filled teeth was 2% lower for each one percent increase in the population under the poverty line (IRR=0.98 95%CI 0.97-1.00) and 18% lower for each 0.01 increase in the HAI score (IRR= 0.87 95%CI 0.82-0.93). On the other hand, the dentist-population ratio had a positive association with the number of filled teeth. The number of filled teeth was 17% higher for each one dentist increase per 100,000 people (IRR=1.17 95%CI 1.07-1.28). Model 7 additionally took living location into account, which did not change the between-province variance. Compared to those who were living in rural areas, adults residing in urban areas had a 1.62 (95%CI 1.30-2.02) times higher number of filled teeth, while there was no difference between rural areas and Bangkok.

Table 7-5 shows the results for the number of filled teeth among 60-74-year old adults. In Model 1, the between-province variance was 0.80, which was statistically significant. Model 2 again shows a strong association between education and the number of filled teeth. Compared to those with no education, older adults who had finished primary school had a 5.86 (95%CI 1.78-19.35) times higher number of filled teeth, while for those who had completed high school there was, on average, a 35-fold increase (95%CI 9.87-124.80). In Model 3, individuals in the highest income group had a 3.11 times higher number of filled teeth compared to those in the lowest group. Controlling for both education and income (Model 4), again only the relationship with education remained statistically significant. Women had a 2.82

(95%CI 1.89-4.20) times higher number of filled teeth compared to men (Model 5). Dental visits were again related to a higher number of filled teeth (IRR for those who had visited once = 1.96, 95%CI 1.22-3.17; IRR for those who visited more than once = 3.21, 95%CI 2.01-5.11). Individuals who had used fluoride toothpaste had a 0.65 (95%CI 0.42-1.00) times lower number of filled teeth compared to those who had not used fluoride toothpaste.

After adjusting for provincial characteristics (Model 6), the between-province variance was decreased to 0.21 but remained statistically significant. Among age group 60-74 years, the number of filled teeth was associated with the dentist per population ratio. The number of filled teeth was 30% higher for each one dentist increase per 100,000 people. Further adjusting for location type (Model 7), the between-province variance slightly decreased but remained statistically significant. The association with the dentist per population ratio became non-significant. Compared to older adults who lived in rural areas, older adults who lived in urban areas had a 5.35 (95%CI 3.53-8.11) times higher number of filled teeth. Again, there was no statistically significant difference between rural areas and Bangkok.

Table 7-4 Results of multilevel negative binomial regression models predicting incidence rate ratio of filled teeth among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
Up to primary		1		1	1	1	1
High school		2.00 (1.58-2.53)***		2.00 (1.57-2.54)***	1.96 (1.55-2.47)***	1.89 (1.50-2.37)***	1.86 (1.48-2.35)***
Bachelor degree/higher		4.60 (3.40-6.24)***		4.24 (3.02-5.94)***	3.41 (2.47-4.71)***	3.35 (2.44-4.61)***	3.11 (2.26-4.29)***
Income							
5000			1	1	1	1	1
5001-15000			1.29 (1.00-1.67)*	0.90 (0.70-1.17)	1.05 (0.82-1.35)	1.05 (0.83-1.34)	1.01 (0.79-1.29)
>15000			2.40 (1.75-3.29)***	1.22 (0.87-1.71)	1.63 (1.17-2.27)**	1.55 (1.12-2.15)**	1.47 (1.07-2.03)*
Age					0.97 (0.93-1.00)*	0.96 (0.93-1.00)*	0.96 (0.93-1.00)*
Female					2.33 (1.90-2.86)***	2.29 (1.87-2.81)***	2.31 (1.88-2.83)***
Dental visit within the past year							
None					1	1	1
1 time					2.07 (1.64-2.60)***	2.06 (1.64-2.59)***	2.01 (1.60-2.52)***
>1 time					2.52 (1.92-3.30)***	2.48 (1.90-3.25)***	2.37 (1.81-3.10)***
Used Fluoride toothpaste							
No					1	1	1
Yes					1.05 (0.84-1.32)	1.05 (0.84-1.32)	1.08 (0.86-1.35)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						0.98 (0.97-1.00)*	0.98 (0.96-1.00)
Dentist : 100,000 population[2]						1.17 (1.07-1.28)**	1.21 (1.08-1.34)**
HAI[3]						0.87 (0.82-0.93)***	0.89 (0.83-0.95)**
GINI[4]						0.99 (0.97-1.02)	1.00 (0.97-1.02)
Location type							
Rural							1
Urban							1.62 (1.30-2.02)***
Bangkok							0.83 (0.42-1.66)
Constant	1.35 (1.04-1.75)*	0.73 (0.57-0.94)*	0.98 (0.74-1.30)	0.75 (0.56-0.99)*	0.27 (0.18-0.39)***	0.26 (0.19-0.36)***	0.23 (0.16-0.32)***
Between province variance	0.24 (0.10)***	0.16 (0.07)***	0.18 (0.08)***	0.16 (0.07)***	0.16 (0.07)***	0.01 (0.02)[NS]	0.02 (0.02)[NS]
Overdispersion parameter	3.62	3.07	3.45	3.05	2.45	2.45	2.37

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table 7-5 Results of multilevel negative binomial regression models predicting incidence rate ratio of filled teeth among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
No education		1		1	1	1	1
Primary school		5.86 (1.78-19.35)**		5.79 (1.75-19.13)**	6.09 (1.80-20.58)**	6.20 (1.85-20.80)**	4.52 (1.30-15.76)*
High school/higher		35.1 (9.87-124.8)***		31.0 (8.62-111.3)***	30.1 (8.38-108.2)***	31.1 (8.72-111.2)***	19.7 (5.39-72.07)***
Income							
5000			1	1	1	1	1
5001-15000			1.22 (0.73-2.04)	1.09 (0.67-1.77)	1.22 (0.76-1.98)	1.21 (0.75-1.96)	1.05 (0.66-1.68)
>15000			3.11 (1.57-6.14)**	1.56 (0.80-3.02)	1.93 (1.02-3.64)*	1.97 (1.04-3.73)**	2.12 (1.16-3.88)*
Age					0.98 (0.93-1.02)	0.98 (0.93-1.03)	0.95 (0.91-1.00)
Female					2.82 (1.89-4.20)***	2.74 (1.84-4.07)***	2.78 (1.88-4.10)***
Dental visit within the past year							
None					1	1	1
1 time					1.96 (1.22-3.17)**	1.92 (1.20-3.09)**	1.83 (1.16-2.91)*
>1 time					3.21 (2.01-5.11)***	3.25 (2.04-5.18)***	3.45 (2.20-5.39)***
Used Fluoride toothpaste							
No					1	1	1
Yes					0.65 (0.42-1.00)*	0.62 (0.40-0.95)*	0.78 (0.51-1.18)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						1.00 (0.96-1.05)	0.98 (0.94-1.03)
Dentist : 100,000 population[2]						1.30 (1.02-1.66)*	1.26 (0.98-1.62)
HAI[3]						0.87 (0.74-1.03)	0.85 (0.72-1.01)
GINI						0.99 (0.93-1.06)	0.99 (0.93-1.05)
Location type[4]							
Rural							1
Urban							5.35 (3.53-8.11)***
Bangkok							3.31 (0.70-15.7)
Constant	0.34 (0.21-0.55)***	0.04 (0.01-0.14)***	0.29 (0.18-0.45)***	0.04 (0.01-0.13)***	0.02 (0.004-0.06)***	0.02 (0.005-0.07)***	0.01 (0.002-0.03)***
Between province variance	0.80 (0.34)***	0.65 (0.28)***	0.62 (0.27)***	0.61 (0.27)***	0.47 (0.22)***	0.21 (0.13)**	0.19 (0.12)**
Overdispersion parameter	8.62	6.43	8.16	6.37	4.86	4.87	3.80

***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

7.3 Periodontal disease: deep periodontal pocket (≥ 6mm)

Table 7-6 shows results of multilevel binary response models predicting the odds of having one or more deep periodontal pockets (≥6mm) among 35-44-year-old adults. The between-province variance in Model 1 was 0.28, which was statistically significant at 0.01 level. The total variance was 3.43. Therefore, the VPC equals 7.84, meaning that 7.84% of the overall variance in this outcome can be attributed to factors operating at the province level. The probability of having a deep periodontal pocket in the average province was 24%.

After adding education as an explanatory variable (Model 2), the between-province variance and variance partition coefficient remained unchanged. Individuals who finished high school or had a bachelor's degree were 0.40 (95%CI 0.22-0.73) and 0.54 (95%CI 0.25-1.14) times less likely to have deep periodontal pockets, compared to those with only primary education. The association was statistically significant only among those who finished high school. Adding income as an explanatory variable (Model 3), the between-province variance and VPC did not change substantially. No statistically significant association between income and having deep periodontal pockets was found. In Model 4, controlling for both education and income simultaneously, the association with education was slightly attenuated, while the association with income remained non-significant. Additionally controlling for age, sex and oral health-related behaviours (Model 5) did not lead to substantial changes in the between-province variance. Women were 0.46 times less likely to have deep periodontal pockets compared to men. Neither smoking status nor tooth brushing frequency were associated with having deep periodontal pockets in this age group.

Model 6 additionally adjusted for provincial characteristics. A higher provincial poverty level was significantly associated with higher odds of having one or more deep periodontal pockets (OR= 1.05 95%CI 1.00-1.10). In this model, the between-province variance was no longer statistically significant. In the final model (Model 7), further adjusted for location type, the dentist per 100,000 population was associated with having periodontal pockets (OR=1.31 95%CI 1.06-1.64). Location type was not related to having deep periodontal pockets.

Table 7-7 shows results of multilevel binary response models predicting the odds of having deep periodontal pockets among 60-74-year-olds. The between-province variance was 0.62, which was statistically significant at 0.001 level (Model 1). Therefore, 15.86% of the overall variance in this outcome can be attributed to factors operating at the province level. The probability of having deep periodontal pockets in the average province was 10%.

No association between education and having deep periodontal pockets was found among the age group 60-74 (Model 2). Individuals with an income above 15,000 THB were 0.34 times less likely to have deep periodontal pocket compared to those with an income of 5,000 THB or less (Model 3). In Model 4, controlling for both education and income simultaneously, neither education nor income was associated with having deep periodontal pockets. Additionally controlling for age, sex and oral health-related behaviours (Model 5) did not lead to marked changes in the between-province variance and VPC. Age was associated with lower odds of having deep periodontal pockets (OR=0.94 95%CI 0.90-0.99). Neither smoking status nor tooth brushing frequency were associated with having deep periodontal pockets.

Model 6 additionally adjusted for provincial characteristics. The between-province variance decreased to 0.31 (VPC=8.61), which was still statistically significant. Provincial poverty, dentist per population ratio and GINI coefficient were significantly associated with higher odds of having deep periodontal pockets. The odds of having deep periodontal pockets were 6% (OR= 1.06 95%CI 1.00-1.11) higher for each one percent increase in the population under the poverty line, 36% (OR=1.36 95%CI1.04-1.78) higher for each one dentist increase per 100,000 population, and 11% (OR=1.11 95%CI 1.03-1.19) higher for each one percent increase in the GINI coefficient. Location type was not related to having deep periodontal pockets (Model 7).

Table 7-6 Results of multilevel logistic regression models predicting odds of having deep periodontal pocket (≥6mm.) among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n=1,517)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
Up to primary		1		1	1	1	1
High school		0.40 (0.22-0.73)**		0.37 (0.20-0.67)**	0.35 (0.19-0.65)**	0.34 (0.19-0.63)**	0.36 (0.19-0.66)**
Bachelor degree/higher		0.54 (0.25-1.14)		0.48 (0.21-1.08)	0.50 (0.22-1.15)	0.47 (0.20-1.08)	0.50 (0.21-1.19)
Income							
5000			1	1	1	1	1
5001-15000			1.37 (0.78-2.42)	1.71 (0.95-3.07)	1.61 (0.89-2.91)	1.71 (0.94-3.12)	1.72 (0.94-3.12)
>15000			0.98 (0.45-2.12)	1.37 (0.59-3.18)	1.15 (0.48-2.72)	1.26 (0.53-3.01)	1.28 (0.54-3.07)
Age					1.04 (0.95-1.13)	1.03 (0.94-1.13)	1.03 (0.95-1.13)
Female					0.46 (0.25-0.84)*	0.46 (0.26-0.85)*	0.47 (0.26-0.85)*
Smoking status							
Non-smoker					1	1	1
Ex-smoker					0.82 (0.33-2.05)	0.79 (0.32-1.98)	0.77 (0.31-1.92)
Current-smoker					0.85 (0.43-1.68)	0.86 (0.44-1.68)	0.85 (0.43-1.67)
Brushing at least twice a day							
No					1	1	1
Yes					1.11 (0.46-2.70)	1.11 (0.46-2.69)	1.10 (0.45-2.67)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						1.05 (1.00-1.10)*	1.06 (1.01-1.10)*
Dentist : 100,000 population[2]						1.26 (0.99-1.59)	1.31 (1.06-1.64)*
HAI[3]						0.95 (0.80-1.12)	0.99 (0.84-1.17)
GINI[4]						1.06 (0.99-1.14)	1.06 (1.00-1.13)
Location type							
Rural							1
Urban							0.91 (0.51-1.62)
Bangkok							0.30 (0.06-1.44)
Constant	0.04 (0.03-0.06)***	0.06 (0.04-0.10)***	0.04 (0.02-0.06)***	0.05 (0.03-0.08)***	0.07 (0.02-0.20)***	0.07 (0.02-0.19)***	0.08 (0.03-0.22***
Between province variance	0.28 (0.18)**	0.28 (0.19)**	0.27 (0.18)**	0.25 (0.18)*	0.26 (0.18)**	0.12 (0.13)	0.05 (0.11)
VPC (%)	7.84	7.84	7.58	7.06	7.32	3.52	1.50

Variance Partition Coefficient (VPC)=% of unexplained variance due to province ***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line

[2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index

[4] unit = 1 percent of GINI index

Table 7-7 Results of multilevel logistic regression models predicting odds of having deep periodontal pocket (≥6mm.) among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
No education		1		1	1	1	1
Primary school		0.94 (0.48-1.82)		0.94 (0.49-1.83)	0.78 (0.39-1.54)	0.82 (0.42-1.62)	0.83 (0.42-1.66)
High school/higher		0.63 (0.27-1.50)		0.70 (0.29-1.70)	0.61 (0.25-1.49)	0.64 (0.26-1.56)	0.65 (0.26-1.65)
Income							
5000			1	1	1	1	1
5001-15000			1.50 (0.97-2.32)	1.54 (0.99-2.39)	1.39 (0.88-2.19)	1.43 (0.91-2.26)	1.43 (0.91-2.26)
>15000			0.34 (0.12-0.96)*	0.37 (0.13-1.08)	0.31 (0.10-0.90)*	0.33 (0.11-0.98)*	0.33 (0.11-0.97)*
Age					0.94 (0.90-0.99)*	0.95 (0.90-0.99)*	0.95 (0.90-0.99)*
Female					0.73 (0.46-1.14)	0.74 (0.47-1.16)	0.74 (0.47-1.16)
Smoking status							
Non-smoker					1	1	1
Ex-smoker					0.74 (0.38-1.42)	0.74 (0.39-1.43)	0.73 (0.38-1.42)
Current-smoker					0.78 (0.44-1.40)	0.79 (0.44-1.40)	0.78 (0.44-1.40)
Brushing at least twice a day							
No					1	1	1
Yes					0.77 (0.49-1.22)	0.77 (0.48-1.21)	0.77 (0.48-1.22)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						1.06 (1.00-1.11)*	1.06 (1.01-1.11)*
Dentist : 100,000 population[2]						1.36 (1.04-1.78)*	1.37 (1.03-1.82)*
HAI[3]						0.92 (0.77-1.10)	0.93 (0.77-1.12)
GINI[4]						1.11 (1.03-1.19)**	1.11 (1.03-1.19)**
Location type							
Rural							1
Urban							0.96 (0.62-1.49)
Bangkok							0.80 (0.12-5.29)
Constant	0.11 (0.07-0.18)***	0.13 (0.06-0.27)***	0.11 (0.07-0.17)***	0.12 (0.06-0.25)***	0.22 (0.09-0.56)**	0.21 (0.09-0.51)**	0.21 (0.09-0.53)**
Between province variance	0.62 (0.32)***	0.63 (0.32)***	0.63 (0.23-1.74)***	0.64 (0.33)***	0.64 (0.33)***	0.31 (0.20)***	0.31 (0.20)***
VPC (%)	15.86	16.07	16.07	16.28	16.28	8.61	8.61

Variance Partition Coefficient (VPC)=% of unexplained variance due to province ***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line

[2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index

[4] unit = 1 percent of GINI index

7.4 Tooth loss

7.4.1 Outcome: Having less than 20 teeth remaining (non-functional dentition)

Table 7‑8 shows the results of multilevel binary response models predicting the odds of having less than 20 teeth (non-functional dentition) among 35-44-year-old adults. Model 1, the empty model, indicates that the between-province variance of having less than 20 teeth was 0.31, which was not statistically significant. Therefore, it means that the odds of having less than 20 teeth remaining did not vary between provinces. The probability of having a non-functional dentition in the average province was 24%.

In Model 2, Model 3, and Model 4 controlling for education and income, the between-province variance remained non-significant. Neither education nor income were associated with having less than 20 teeth remaining. Additionally, controlling for age, sex and oral health-related behaviours in Model 5 did not lead to changes in the between-province variance. The results showed a statistically significant positive association between age and having less than 20 teeth.

Model 5 and Model 6 were additionally adjusted for provincial characteristics and location type. The between-province variance remained non-significant. Moreover, none of the area-level characteristics was associated with having less than 20 teeth remaining among the 35-44 age group.

Table 7‑9 shows results of multilevel binary response models predicting the odds of having less than 20 teeth (a non-functional dentition) among 60-74-year old adults. Model 1, the empty model, indicates that the between-province variance of having

less than 20 teeth was 0.14, which was statistically significant at 0.001 level. The VPC equals 4.08, meaning that 4.1% of the overall variance in this outcome can be attributed to factors operating at the province level. The probability of having a non-functional dentition in the average province for this age group was 36%.

After adding education and income as explanatory variables (Model 2 and 3), the between-province variance and variance partition coefficient did not markedly change. Neither education nor income were associated with having less than 20 teeth remaining in this age group. In Model 4, controlling for both education and income simultaneously, the between-province variance was slightly increased (VPC = 5.2%). The association with education remained non-significant, however, in this model, adults in the high-income group had 40% lower odds of having less than 20 teeth compared to those in the low-income group (OR=0.60; 95%CI 0.37-0.97). Additionally controlling for age, sex and oral health-related behaviours (Model 5) did not lead to marked changes in the between-province variance. The results showed a statistically significant positive association between age group and having less than 20 teeth. Compared to those who did not visit a dentist, individuals who visited a dentist once during the past year were 53% (OR=1.53 95%CI 1.10-2.13) more likely to have less than 20 teeth, while for those who visited more than once this was 64% (OR=1.64 95%CI 1.17-2.31) Furthermore, being a current smoker increased the odds of having less than 20 teeth by 75% (OR=1.75 95%CI 1.18-2.59).

Model 6 was additionally adjusted for provincial characteristics. The between-province variance was reduced to 0.09 but remained statistically significant (VPC = 2.66). None of the provincial characteristics were associated with having less than 20 teeth remaining. In the final model (Model 7), further adjusted for location type, the between-province variance slightly decreased but remained statistically significant

(VPC=2.08). People living in urban areas were 87% (OR=1.87 95%CI 1.41-2.50) more likely to have less than 20 teeth. People living in Bangkok were 41% (OR=0.59 95%CI 0.21-1.66) less likely to have less than 20 teeth compared with those living in rural areas however this difference was not statistically significant.

Table 7-8 Results of multilevel logistic regression models predicting odds of having less than 20 teeth (non-functional dentition) among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n=1,517).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
Up to primary		1		1	1	1	1
High school		0.70 (0.33-1.52)		0.72 (0.33-1.59)	0.78 (0.35-1.75)	0.75 (0.33-1.68)	0.75 (0.33-1.69)
Bachelor degree/higher		0.63 (0.21-1.93)		0.94 (0.28-3.15)	1.07 (0.30-3.74)	1.04 (0.29-3.65)	1.03 (0.29-3.70)
Income							
5000			1	1	1	1	1
5001-15000			1.10 (0.51-2.35)	1.15 (0.52-2.54)	1.16 (0.51-2.62)	1.06 (0.47-2.41)	1.06 (0.47-2.40)
>15000			0.29 (0.06-1.32)	0.29 (0.06-1.50)	0.26 (0.05-1.36)	0.23 (0.04-1.22)	0.22 (0.04-1.21)
Age					1.25 (1.09-1.44)**	1.25 (1.08-1.44)**	1.25 (1.08-1.44)**
Female					1.50 (0.57-3.96)	1.46 (0.56-3.82)	1.43 (0.54-3.78)
Dental visit within the past year							
None					1	1	1
1 time					1.21 (0.51-2.87)	1.23 (0.52-2.92)	1.24 (0.52-2.94)
>1 time					1.75 (0.69-4.47)	1.73 (0.68-4.42)	1.69 (0.66-4.32)
Smoking status							
Non-smoker					1	1	1
Ex-smoker					1.49 (0.36-6.22)	1.59 (0.38-6.57)	1.56 (0.38-6.45)
Current-smoker					1.39 (0.43-4.45)	1.38 (0.43-4.38)	1.35 (0.42-4.34)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						0.96 (0.90-1.03)	0.97 (0.91-1.04)
Dentist : 100,000 population[2]						0.97 (0.69-1.36)	1.05 (0.74-1.49)
HAII						0.94 (0.75-1.17)	0.99 (0.78-1.25)
GINI						0.95 (0.86-1.05)	0.95 (0.87-1.05)
Location type							
Rural							1
Urban							1.41 (0.66-3.02)
Bangkok							0.31 (0.02-3.82)
Constant	0.02 (0.01-0.03)***	0.02 (0.01-0.04)***	0.02 (0.01-0.04)***	0.02 (0.01-0.05)***	0.01 (0.004-0.04)***	0.01 (0.004-0.04)***	0.01 (0.004-0.04)***
Between province variance	0.31 (0.30)^{NS}	0.32 (0.30)^{NS}	0.32 (0.30)^{NS}	0.32 (0.30)^{NS}	0.35 (0.32)^{NS}	0.19 (0.26)^{NS}	0.16 (0.24)^{NS}
VPC (%)	8.61	8.86	8.86	8.86	9.62	5.46	4.64

Variance Partition Coefficient (VPC)=% of unexplained variance due to province ***p<0.001 **p<0.01 *p<0.05 ^{NS} Random effect not statistically significant

[1] unit = one percent of population under the poverty line

[2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index

[4] unit = 1 percent of GINI index

Table 7-9 Results of multilevel logistic regression models predicting odds of having less than 20 teeth (non-functional dentition) among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
No education		1		1	1	1	1
Primary school		0.85 (0.53-1.35)		0.87 (0.55-1.39)	1.07 (0.66-1.73)	1.03 (0.64-1.66)	0.94 (0.58-1.53)
High school/higher		0.92 (0.52-1.61)		1.07 (0.60-1.90)	1.19 (0.65-2.16)	1.15 (0.63-2.09)	0.92 (0.50-1.70)
Income							
5000			1	1	1	1	1
5001-15000			0.80 (0.59-1.10)	0.79 (0.58-1.09)	0.86 (0.62-1.20)	0.87 (0.62-1.21)	0.87 (0.62-1.21)
>15000			0.63 (0.39-1.01)	0.60 (0.37-0.97)*	0.63 (0.38-1.04)	0.62 (0.38-1.03)	0.66 (0.40-1.10)
Age					1.07 (1.04-1.10)***	1.07 (1.04-1.11)***	1.07 (1.03-1.10)***
Female					1.35 (0.99-1.84)	1.34 (0.98-1.82)	1.40 (1.03-1.91)*
Dental visit within the past year							
None					1	1	1
1 time					1.53 (1.10-2.13)*	1.52 (1.09-2.12)*	1.51 (1.08-2.11)*
>1 time					1.64 (1.17-2.31)**	1.63 (1.16-2.29)**	1.63 (1.16-2.31)**
Smoking status							
Non-smoker					1	1	1
Ex-smoker					1.04 (0.68-1.60)	1.03 (0.67-1.58)	1.12 (0.73-1.74)
Current-smoker					1.75 (1.18-2.59)**	1.74 (1.17-2.57)**	1.91 (1.28-2.85)**
Contextual-level							
Provincial Poverty Headcount Ratio[1]						0.98 (0.95-1.01)	0.99 (0.96-1.02)
Dentist : 100,000 population[2]						1.04 (0.89-1.22)	1.09 (0.94-1.28)
HAII						0.91 (0.82-1.01)	0.93 (0.84-1.02)
GINI						0.97 (0.93-1.01)	0.97 (0.93-1.01)
Location type							
Rural							1
Urban							1.87 (1.41-2.50)***
Bangkok							0.59 (0.21-1.66)
Constant	0.57 (0.46-0.71)***	0.66 (0.41-1.06)	0.62 (0.49-0.80)***	0.69 (0.43-1.13)	0.37 (0.21-0.67)**	0.39 (0.22-0.68)**	0.35 (0.20-0.61)***
Between province variance	0.14 (0.07)***	0.14 (0.07)***	0.17 (0.09)***	0.18 (0.09)***	0.19 (0.09)***	0.09 (0.06)**	0.07 (0.05)*
VPC (%)	4.08	4.08	4.91	5.19	5.46	2.66	2.08

Variance Partition Coefficient (VPC)=% of unexplained variance due to province ***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line

[2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index

[4] unit = 1 percent of GINI index

7.4.2 Outcome: Edentulousness (complete tooth loss)

Table 7‑10 shows results of multilevel binary response models predicting the odds of being edentulous among 60-74-year old adults. The between-province variance of being edentulous was 0.14, which was statistically significant at 0.05 level. The total variance was 3.43. Therefore, the VPC equals 4.08. The probability of being edentulous in the average province, for this age group, was 36%.

There was no association between education and being edentulous (Model 2). Adding income as an explanatory variable (Model 3), the between-province variance slightly increased to 0.19 and remained statistically significant (VPC=5.46). Adults in the high-income group had 70% lower odds of being edentulous compared to those in the low-income group (OR=0.30; 95%CI 0.09-0.98). In Model 4, controlling for both education and income simultaneously, the association with education remained non-significant, while the association with income did not markedly change. Additionally controlling for age, sex and oral health-related behaviours (Model 5) did not lead to change in the between-province variance. The results showed a statistically significant positive association between age and being edentulous (OR=1.12; 95%CI 1.06-1.18). Compared to those who did not visit a dentist, individuals who visited a dentist once during the past year were 72% (OR=0.28; 95%CI 0.11-0.70) less likely to be edentulous.

Model 6 was additionally adjusted for provincial characteristics. The between-province variance was reduced to 0.02 and became non-significant. None of the provincial characteristics was however significantly associated with being edentulous. In the final model (Model 7), further adjusted for living location, the between-province

variance remained non-significant. People living in urban areas were 64% (OR=1.64; 95%CI 1.00-2.67) more likely to be edentulous compared to those in rural areas.

Table 7-10 Results of multilevel logistic regression models predicting odds of being edentulous among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,264).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Individual-level							
Education							
No education		1		1	1	1	1
Primary school		1.28 (0.53-3.06)		1.34 (0.56-3.23)	1.83 (0.75-4.49)	1.83 (0.75-4.47)	1.74 (0.71-4.29)
High school/higher		1.07 (0.37-3.05)		1.38 (0.47-4.03)	1.80 (0.60-5.44)	1.82 (0.61-5.42)	1.67 (0.54-5.14)
Income							
5000			1	1	1	1	1
5001-15000			0.76 (0.44-1.32)	0.75 (0.43-1.31)	0.92 (0.52-1.64)	0.89 (0.50-1.57)	0.87 (0.49-1.54)
>15000			0.30 (0.09-0.98)*	0.29 (0.09-0.97)*	0.37 (0.11-1.28)	0.38 (0.11-1.31)	0.38 (0.11-1.33)
Age					1.12 (1.06-1.18)***	1.12 (1.06-1.18)***	1.12 (1.06-1.18)***
Female					1.23 (0.72-2.10)	1.20 (0.71-2.03)	1.20 (0.71-2.05)
Dental visit within the past year							
None					1	1	1
1 time					0.28 (0.11-0.70)**	0.27 (0.11-0.69)**	0.27 (0.11-0.69)**
>1 time					0.88 (0.49-1.60)	0.88 (0.49-1.59)	0.88 (0.49-1.58)
Smoking status							
Non-smoker					1	1	1
Ex-smoker					0.98 (0.45-2.12)	0.93 (0.43-2.01)	0.98 (0.45-2.14)
Current-smoker					1.50 (0.78-2.87)	1.46 (0.77-2.80)	1.55 (0.81-2.98)
Contextual-level							
Provincial Poverty Headcount Ratio[1]						1.00 (0.96-1.03)	1.00 (0.96-1.04)
Dentist : 100,000 population[2]						1.19 (0.98-1.45)	1.22 (1.00-1.50)
HAII						0.91 (0.80-1.03)	0.92 (0.81-1.05)
GINI						0.99 (0.94-1.04)	0.99 (0.94-1.04)
Location type							
Rural							1
Urban							1.64 (1.00-2.67)*
Bangkok							0.78 (0.23-2.61)
Constant	0.07 (0.05-0.10)***	0.06 (0.02-0.14)***	0.08 (0.06-0.11)***	0.06 (0.03-0.15)***	0.04 (0.01-0.11)***	0.04 (0.02-0.11)***	0.04 (0.01-0.10)***
Between province variance	0.14(0.12)[NS]	0.14 (0.13)*	0.19 (0.15)*	0.19 (0.15)*	0.19 (0.15)*	0.02 (0.08)	0.1 (0.08)
VPC (%)	4.08	4.08	5.46	5.46	5.46	0.60	0.30

Variance Partition Coefficient (VPC)=% of unexplained variance due to province ***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line

[2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index

[4] unit = 1 percent of GINI index

7.5 Summary of key findings

The findings from the multilevel analyses are summarised in Tables 7-11 and 7-12. Using multilevel analysis enabled the further exploration of oral health inequalities after accounting for the variation between provinces and adjusting for oral health related behaviours and area-level factors. The results showed statistically significant socio-economic gradients in DMFT, decayed and filled teeth for both age groups. In the fully adjusted model, reverse education and gradients in DMFT, decayed, and filled teeth remained statistically significant. The results also showed statistically significant variations in the examined oral health outcomes between provinces, except for having a non-functional dentition among the 35-44 year olds.

In addition, the results showed independent associations between contextual-level characteristics and oral health. Provincial Poverty Headcount Ratio was positively associated with periodontal disease in both age groups. The dentist: population ratio was positively associated with the number of filled teeth and dental caries experience among 35-44-year-old adults, and positively associated with periodontal disease in both age groups. The HAI score was negatively associated with dental caries experience and the number of filled teeth. The GINI coefficient was positively associated with periodontal disease in the older age group only. Furthermore, the results showed that adults living in urban area were more likely to have higher number of DMFT and filled teeth for both age groups, were less likely to have decayed teeth in age group 60-74 years and were more likely to have tooth loss in age group 60-74 years.

Table 7-11 Summary - results of multilevel negative binomial regression models predicting markers of dental caries.

	DMFT	Decayed teeth		Filled teeth	
	35-44	35-44	60-74	35-44	60-74
Random effect					
Between-province variance (empty model)	0.11***	0.26***	0.10***	0.24***	0.80***
Between-province variance (fully adjusted model)	0.03***	0.12***	0.06***	0.02^{NS}	0.19**
Statistically significant between-province variance after adjusting for individual-level covariates?	***	***	***	***	***
Statistically significant between-province variance after adjusting for provincial-level covariates?	***	***	***	NS	**
Fixed effect: individual-level SEP					
Education gradient					
Model 2 (only education)	$(+)^{h}$	(-)***	(-)***	(+)***	(+)***
Model 4 (education and Income)	$(+)^{h}$	(-)***	(-)***	(+)***	(+)***
Model 5 (all individual factors)	$(+)^{h}$	(-)***	$(-)^{h}$	(+)***	(+)***
Model 7 (fully adjusted model)	$(+)^{h}$	(-)***	$(-)^{NS}$	(+)***	(+)***
Income gradient					
Model 3 (only income)	$(+)^{h}$	(-)***	$(x)^{NS}$	(+)***	$(+)^{h}$
Model 4 (education and Income)	$(+)^{NS}$	$(-)^{NS}$	$(x)^{NS}$	$(x)^{NS}$	$(+)^{NS}$
Model 5 (all individual factors)	$(+)^{NS}$	$(-)^{NS}$	$(x)^{NS}$	$(+)^{h}$	$(+)^{h}$
Model 7 (fully adjusted model)	$(+)^{NS}$	$(-)^{NS}$	$(x)^{NS}$	$(+)^{h}$	$(+)^{h}$
Fixed effect: provincial-level characteristics					
Provincial Poverty Headcount Ratio	NS	NS	NS	NS	NS
Dentist: 100,000 populations	+	NS	NS	+	NS
HAI	-	NS	NS	-	NS
GINI	NS	NS	NS	NS	NS
Urban/rural					
urban	+	NS	-	+	+
Bangkok	NS	NS	NS	NS	NS

(+)=positive gradient (-) =negative gradient (x)=no gradient
***=Clear gradient ^{h} =Significant associaton among high SES ^{NS} =non-significant association
N/A=Not available

Table 7-12 Summary - results of multilevel logistic regression models predicting markers of deep periodontal pocket, non-functional dentition and edentulousness.

	Deep pocket		< 20 teeth		Edentulous
	35-44	60-74	35-44	60-74	60-74
Random effect					
Baseline probability (unadjusted constant)	3.8% (0.04)	9.9% (0.11)	2.0% (0.02)	36.3% (0.57)	6.5% (0.07)
VPC (%)- empty model	7.84	15.86	8.61	4.08	4.08
VPC (%)- fully adjusted model	1.50	8.61	4.64	2.08	0.30
Statistically significant between-province variance after adjusting for individual-level covariates?	**	***	NS	***	*
Statistically significant between-province variance after adjusting for provincial-level covariates?	NS	***	NS	*	NS
Fixed effect: individual-level SEP					
Education gradient					
Model 2 (only education)	(x)^{m}	(-)^{NS}	(-)^{NS}	(x)^{NS}	(x)^{NS}
Model 4 (education and Income)	(x)^{m}	(-)^{NS}	(x)^{NS}	(x)^{NS}	(+)^{NS}
Model 5 (all individual factors)	(x)^{m}	(-)^{NS}	(x)^{NS}	(+)^{NS}	(x)^{NS}
Model 7 (fully adjusted model)	(x)^{m}	(-)^{NS}	(x)^{NS}	(-)^{NS}	(x)^{NS}
Income gradient					
Model 3 (only income)	(x)^{NS}	(x)^{h}	(x)^{NS}	(-)^{NS}	(-)^{h}
Model 4 (education and Income)	(x)^{NS}	(x)^{NS}	(x)^{NS}	(-)^{h}	(-)^{h}
Model 5 (all individual factors)	(x)^{NS}	(x)^{h}	(x)^{NS}	(-)^{NS}	(-)^{NS}
Model 7 (fully adjusted model)	(x)^{NS}	(x)^{h}	(x)^{NS}	(-)^{NS}	(-)^{NS}
Fixed effect: provincial-level characteristics					
Provincial Poverty Headcount Ratio	+	+	NS	NS	NS
Dentist: 100,000 populations	+	+	NS	NS	NS
HAI	NS	NS	NS	NS	NS
GINI	NS	+	NS	NS	NS
Urban/rural					
urban	NS	NS	NS	NS	+
Bangkok	NS	NS	NS	NS	NS

(+)=positive gradient (-) =negative gradient (x)=no gradient

***=Clear gradient ^{m} =Significant associaton among middle SES ^{h} =Significant associaton among high SES

^{NS} =non-significant association

N/A=Not available

Chapter 8 Discussion

The main aim of this thesis was to assess social inequalities in oral health among a nationally representative sample of Thai adults aged 35-44 and 60-74 years. This chapter first presents the main findings of this research, then key results for each oral health outcome are discussed and compared with other studies, followed by the strengths and limitations of the study. Policy implications are considered before providing an overall research conclusion.

8.1 Summary of main findings

This study provided important evidence on inequalities in oral health among Thai adults. The results showed unexpected reversed social gradients in DMFT. On average, adults with higher socio-economic position, defined by level of education and income, had a higher DMFT than those with a lower SEP, which was driven by reversed social gradients in the number of filled teeth. In addition, the results showed social gradients in the prevalence of untreated dental caries in the expected direction by education, and among 35-44-year olds, also by income. In relation to periodontal disease, the results showed education and income gradients in the prevalence of deep periodontal pockets, however only the education gradient among the age group 35-44 years was statistically significant. In terms of tooth loss, there were statistically significant education and income gradients in having a non-functional dentition only among 35-44-year-old adults, and an income gradient in edentulousness only among 60-74-year-old adults.

At the regional level, the descriptive analysis showed differences in oral health status between regions, which were similar for both age groups. On average, respondents living in richer regions, including central and Bangkok regions, had a higher DMFT, more filled teeth, and lower levels of periodontal disease. Among the older age group, the prevalence of edentulousness was higher in richer regions. Respondents living in the Northern and Southern regions (middle poverty) had the lowest levels of decay and highest prevalence of non-functional dentition.

The multilevel analyses showed statistically significant variations between provinces for all oral health outcomes, except for having a non-functional dentition among 35-44 year olds. Furthermore, the results showed independent associations between contextual-level characteristics and oral health. Those living in poorer provinces were more likely to have periodontal disease, in both age groups. The number of dentists per 100,000 population was positively associated with the number of filled teeth and DMFT among 35-44 year olds, and with higher levels of periodontal disease in both age groups. The Human Achievement Index (HAI) score was negatively associated with dental caries experience and the number of filled teeth. The GINI coefficient was positively associated with periodontal disease among 60-74 year olds.

8.2 Social gradients in dental caries

8.2.1 Individual-level factors (education and income)

Among age group 35-44 years, the analyses showed unexpected reverse income and education gradients for the DMFT. However, regarding the education gradient, a significant difference was found only between the highest (bachelor's degree and higher) and the lowest (up to primary) education group. Although most studies reported social gradients in the opposite direction (Costa et al., 2012; Schwendicke et al., 2015), there are some studies from other developing countries with findings similar to the present study. Varenne et al. (2006) conducted a study among adults aged 35-44 years living in Burkina Faso and reported reversed gradient in DMFT: adults with a higher level of education were more likely to have a higher DMFT. Higher DMFT levels among more privileged groups were also found among 12-year-old-children in Thailand and Laos (Jürgensen and Petersen, 2009; Petersen et al., 2001).

For the number of decayed teeth, as expected, the results showed that the lower socio-economic groups had more untreated decay. Among age group 35-44, there were education and income gradients in decayed teeth. Similar gradients in dental caries were also found in Australia (Mejia et al., 2014), Israel (Sgan-Cohen et al., 1999), and the United Kingdom (Steele et al., 2015). Negative associations between decayed teeth and socio-economic position among adults were also found in other developing countries, such as, Lebanon (Doughan et al., 2000), Iran (Hessari et al., 2007), and India (Chandra Shekar and Reddy, 2011).

Regarding the filled teeth component, results from the zero-inflated negative binomial regression showed that a higher education and income were associated with lower odds of having no filled teeth and a higher number of filled teeth. Further, there were

education and income gradients in the number of filled teeth. Those in higher socio-economic groups having more filled teeth was also reported in other studies, including from Denmark (Krustrup et al., 2008), Iran (Hessari et al., 2007), and India (Chandra Shekar and Reddy, 2011).

When variation between provinces was taken into account, significant differences in DMFT were found only between the highest and the lowest education and income groups. In addition, multilevel models persistently showed education and income gradients in decayed teeth and reversed education and income gradients in filled teeth.

Compared to adults aged 35-44 years, respondents aged 60-74 years had on average more untreated decayed teeth. In the older age group, a social gradient in decayed teeth was found only by education but not income. Education gradients in decayed teeth among older adults were also found in both developed and developing countries (Joaquim et al., 2010; Krustrup et al., 2008). The non-significant association between decay and income among 60-74-year olds may be due to income not accurately reflecting the socio-economic position of older people who might be retired and therefore have a lower income than they had while working.

Respondents aged 60-74 years had on average fewer filled teeth compared to those aged 35-44 years. The results show reversed education and income gradients in filled teeth. However, only the differences between the highest and the lowest groups were statistically significant. The differences in mean number of filled teeth between the highest and the lowest socio-economic groups were larger among older age group. This was similar to the study among a nationally representative sample of Australian adults (Mejia et al., 2014). This could be explained by the fact that fillings are

irreversible, and inequality in access and utilization of dental services accumulates over the life course.

Multilevel models showed similar results. Regarding filled teeth, Incidence Rates Ratios had remarkably wide confidence intervals for the highest education groups, due to the small number of elderly with a high level of education (high school/higher). In 2012, the mean years of schooling were 8.8 years among 15-59 year olds but only 4.5 years among those aged 60 and over (Office of the Education Council, 2017).

For both age groups, when both education and income were added into the model simultaneously, the associations between income and all dental caries outcomes became non-significant and only education gradients persisted. This suggests that education is playing a more important role than income for the caries experience of Thai adults.

As expected, there were social gradients in untreated dental caries. However, the DMFT followed reverse gradients by education and income, which were driven by the number of filled teeth. The mean number of filled teeth was more than 4 times higher in the highest compared to the lowest education and income groups in both age groups. There are two possible reasons for this finding.

First, it might be that the higher number of filled teeth among more affluent adults were due to overtreatment. The number of filled teeth was associated with the number of dental visits, which in turn was associated with education and income. This suggests that adults with higher income and education had better access to and were also more likely to use dental health services. These results are similar to a previous Thai study, which suggested that those with higher incomes were more likely to use dental services (Somkotra, 2013). Sheiham et al. (1985) also suggested that higher

dental attendance is related to a higher number of filled teeth. In addition, there is evidence that unnecessary restorative treatment, such as enamel caries restoration, is more likely to be provided by large private practices due to financial incentives (Fellows et al., 2014; Grembowski et al., 1997). The present data also showed that respondents aged 35-44 with higher education and income were more likely to use private dental services (Table A-16), a finding that has also been reported previously (Somkotra and Detsomboonrat, 2009). There is also evidence suggesting that dentist's reimbursement and patient's remuneration systems are both related to dentist's clinical activities (Brocklehurst et al., 2013; Chalkley and Listl, 2018). In Thailand, there are three main health insurance schemes, including Civil Servant Medical Benefit Scheme (CSMBS), social security scheme (SSS) and Universal coverage scheme (UCS) (Thammatach-aree, 2011). The data showed that the type of health insurance scheme used by the respondents was related to their DMFT, decayed and filled teeth; respondents with CSMBS had higher DMFT and filled teeth, and lower decayed teeth on average. The different characteristics between these schemes, including type of service provider and treatment covered, and budget limitations, may influence dentist's clinical decisions which may then lead to inequalities in oral health status.

The Civil Servant Medical Benefit Scheme (CSMBS) was first introduced in 1980 covering all government officers and their dependants, including parents, spouses, and their children age under 18 years (Thammatach-aree, 2011). The package covers a variety of dental treatment e.g. tooth cleaning, filling, extraction, root canal treatment, removable and fixed prosthesis. The CSMBS members can receive services at any public hospitals, including both clinics during the working hours and extended hours. The benefits of this scheme are not only being flexible on type of treatment and service facility but also its reimbursement method, which is fee-for-

service. Fee-for-service is an incentive-based remuneration system. The dentist or hospital is paid for every unit of service they deliver; more treatment they provide means more income they earn. All these characteristics could lead to higher dental service utilisation and be possible cause of over treatment among this groups. The data also showed that respondents with CSMBS were related to high education level (Table A-15). The Social Security Scheme covers all employees in the private sector. Although insured persons need to be registered in the contract hospital, insured persons can receive dental treatment at any provider, including both public and private providers. The provider is paid by fee-for-service remuneration systems, however the budget is limited in 900 THB/year (approximately 28 USD/year). The Universal Coverage Scheme (UCS) has been introduced since 2001 in order to reduce inequality in health and health service utilization. This scheme covers all Thai population that are not covered by CSMBS and SSS, mostly those belonging to low socio-economic groups. Although the package covers all the basic dental treatment, including tooth cleaning, filling and tooth extraction (Somkotra and Detsomboonrat, 2009), the data shows that respondents with UCS still had more decayed teeth, less filled teeth and were less likely to visit dentist during the past year. This might be because the free provision of dental treatment is limited only to their own registered hospitals and the dentist payment method is salary which may lead to low clinical activities.

Second, the higher number of filled teeth among the higher socio-economic groups might be due to them actually having higher levels of dental caries and receiving treatment. A possible explanation of higher caries levels among the more privileged could be the nutrition transition in developing countries. Popkin (2003) suggested that the nutrition transition consisted of three stages; decreasing food shortage as income increased, dietary shifts and increases in non-communicable diseases, and reversed

behavioural change to achieve healthy aging. In Thailand, during the last decade, the traditional diet, which mainly consisted of rice, vegetables and fish, has been replaced by a western diet and ready-to-eat food, which consists of meat and ingredients high in fat and sugar, especially among higher socio-economic groups who are able to afford those foods (Kelly et al., 2010; Kosulwat, 2006). Unhealthy lifestyles have also been linked to similar reversed trends in other non-communicable diseases among Thai adults. For example, adults with higher education and income levels were more likely to have hypercholesterol (Pipatvanichgul et al., 2015), overweight and obesity, diabetes (Aekplakorn et al., 2014; Jitnarin et al., 2010), and hypertension (Thawornchaisit et al., 2013b). A recent study reported an increase in healthy diets among the more affluent Thai population (Papier et al., 2017), which would explain the lower levels of untreated caries among the high socio-economic groups in this present study. However, a filling is an irreversible treatment, so those in higher socio-economic groups may still have more filled teeth.

8.2.2 Provincial-level factors

The multilevel analysis showed that there were variations in dental caries between provinces. The results also showed that there were associations between provincial characteristics and dental caries independently from the effect of individual-level characteristics.

The number of dentists per 100,000 population was positively associated with DMFT and the number of filled teeth, suggesting that adults living in a province with a higher number of dentists had better access to dental treatment. Previous research also suggested that the availability of dental health services, defined by the dentist per

population ratio in the area, is related with dental attendance (Millar and Locker, 1999).

The Human Achievement Index (HAI), which is similar to the Human Development Index and was developed to compare human development at the provincial level in Thailand, was negatively associated with DMFT and filled teeth. It is possible to hypothesise that living in a place that had advanced human development reduces the likelihood of dental caries, meaning fewer filled teeth. Roncalli et al. (2014) suggested that higher municipal HDI score was related to lower needs for restorative treatment. Besides, living in an area with higher HDI means higher likelihood of better living conditions, quality of life and possibly better access to more skilled dental practitioners or conservative dental treatments (Chalub et al., 2016).

Living in an urban area was associated with higher DMFT and more filled teeth in both age groups. Similar results were found in Lebanon (Doughan et al., 2000), Lithuania (Skudutyte et al., 2000), and Iran (Hessari et al., 2007). These results showed that individuals living in urban areas benefitted from being close to dental services. The present analysis also showed that living in an urban area was associated with fewer decayed teeth for older adults. A possible explanation for this result is that access to a hospital or dental clinic is more difficult in rural or remote areas, and that this is more problematic for older than for younger adults. In addition, after adjusting for urban/rural status, the associations between education and decayed teeth among 60-74-year olds became non-significant. One explanation might be that older adults who live in urban areas are more likely to have higher education compared to those in rural areas (Office of the Education Council, 2017).

In summary, the results showed unexpected reverse gradients in dental caries experience (DMFT), which were driven by the reverse social gradients in filled teeth. Individuals who had higher education and income and were living in more privileged areas appeared to have better access to dental health services, which would explain lower caries levels and higher number of filled teeth and DMFT.

8.3 Social gradients in periodontal disease

8.3.1 Individual-level factors (education and income)

Results from single-level regression analyses showed social gradients by education in the prevalence of periodontal disease (having deep periodontal pockets) among both age groups and a gradient by income among those aged 35-44 years only. Although no linear gradient by income was found among those aged 60-74 years, the results also showed that those belonging to the highest income group were less likely to have periodontal disease compared to the lowest income group. Inequalities in periodontal disease were also found in other Thai studies (Torrungruang et al., 2009; Torrungruang et al., 2005) and similar socio-economic gradients were also reported in nationally representative samples from developing countries, such as Vietnam (Do et al., 2003), Nepal (David et al., 2011), and Uruguay (Lorenzo et al., 2015). These findings suggest that individual-level socio-economic position is related to periodontal health, which might be due to psychological pathways. Adults with low socio-economic position are at higher risk of chronic stress that might affect immune system, induce unhealthy behaviours, such as smoking and alcohol consumption, and therefore, lead to periodontitis (Genco et al., 1999; Sheiham and Nicolau, 2005).

One unanticipated finding was that the results failed to show an association between smoking and presence of deep periodontal pockets in both age groups. Smoking is considered to be a substantial factor for periodontal disease (Klinge et al., 2005; Warnakulasuriya et al., 2010). In this study, descriptive analyses showed that there was no social gradient in smoking status, and smoking did not explain the social gradient in periodontal disease. Smoking status was highly correlated with sex; only two percent of females reported that they were ex-smokers or current smokers. There

was no information about how long or how heavy individuals had been smoking before quitting. In addition, smoking status was collected via an interview that may result in underreporting or reporting bias.

In the multilevel analysis, when both education and income were added simultaneously into the model, having deep periodontal pockets was associated with education only in age group 35-44, and income only in age group 60-74. Those in higher socio-economic groups were less likely to have deep periodontal pockets. Previous studies also showed mixed results. No previous Thai study used multilevel models to assess the associations between socio-economic position and periodontal disease. However, one multilevel study showed non-significant association between individual-level socio-economic measures and periodontal outcomes (Bower et al., 2007), while some studies found statistically significant associations (Celeste et al., 2011; Sun et al., 2016; Vettore et al., 2013).

8.3.2 Provincial-level factors

Multilevel analysis showed variations in the prevalence of periodontal disease between provinces in both age groups. After accounting for provincial-level characteristics, the variation between provinces among age group 35-44 years became non-significant. The analyses also showed independent effects of provincial-level characteristics on having deep periodontal pocket.

Provincial poverty, defined as Provincial Poverty Headcount ratio, was significantly and positively associated with having periodontal pockets among both age groups. Those living in provinces with higher poverty levels were more likely to have deep periodontal pockets. This is consistent with a previous study in Brazil, which also reported that living in less advantaged neighbourhoods was associated with having

periodontal disease (Borrell et al., 2006b). Living in high socio-economic areas could promote behaviours that prevent periodontitis, such as less alcohol consumption and betel nut chewing.

The number of dentists per 100,000 population was positively associated with having deep periodontal pockets. This finding is similar to a previous study from China, which found that living in an area with a high dentist per population ratio increased the odds of having periodontal pockets, however, the associations were not statistically significant (Sun et al., 2016). It might be that having better access to dental treatment means that teeth are retained for longer, which might increase the chance to have periodontitis.

Income inequality, defined by provincial GINI coefficient, was only significantly associated with periodontal disease among age group 60-74 years. Living in areas with higher income inequality was associated with higher odds of having periodontal disease. Similar results were found in Brazil (Vettore et al., 2013). Relative deprivation of goods decreases interpersonal relationships and social cohesion which may result in less access to health information and oral health care services. Another possible mechanism of social inequalities on periodontal conditions is related to the immunosuppressive effect of stress in response to environmental determinants (Sheiham and Nicolau, 2005; Wilkinson and Pickett, 2006). Several studies have described the association between psychosocial factors and periodontal disease (Genco et al., 1999; Sheiham and Nicolau, 2005; Thomson et al., 2012)

In summary, as expected, the results showed socio-economic gradients in periodontal disease. Both individual- and area-level factors were independently associated with periodontitis. Individuals belonging to high socio-economic groups and living in

provinces with low poverty and income inequality were less likely to have periodontal disease.

8.4 Social gradients in tooth loss

8.4.1 Individual-level factors (education and income)

8.4.1.1 Non-functional dentition

Among 35-44 year olds, the results showed education and income gradients in having less than 20 teeth, however, only the differences between the highest and the lowest socio-economic groups were statistically significant. Adults with higher education and income levels were less likely to have a non-functional dentition. Similar results were found in previous studies conducted among Thai adults (Chatrchaiwiwatana et al., 2012; Yiengprugsawan et al., 2011a). Less well-off individuals were more likely to have poor oral hygiene or oral habits, such as smoking, that are related to dental caries and periodontitis, which are the main causes of tooth loss (Burt et al., 1990). Previous studies have also shown that tooth extractions are more common among lower income groups, while individuals with higher incomes are more likely to have more conservative treatment (Klock, 1995).

When variation between provinces was taken into account, neither education nor income remained significantly associated with having a non-functional dentition. These findings are in contrast to previous multilevel studies from Brazil (Chalub et al., 2016; Goulart and Vettore, 2016; Koltermann et al., 2011) which reported significant associations between individual-level socio-economic position and non-functional dentition. The non-significant association found in this study might be a result of low statistical power, as the prevalence of non-functional dentition among 35-44-year olds was only 2.6%.

Among 60-74-year-olds, there was no statistically significant association between socio-economic position and having less than 20 teeth. A previous study from Thailand (Srisilapanan et al., 2016) reported that older adults who had lower socio-economic position were more likely to have a non-functional dentition. The different results might be due to the different socio-economic measures used. The previous study used dichotomized variables of household income (high vs low), possession of durable goods (luxury vs non-luxury), and education (high vs low).

After accounting for variations between provinces, having a non-functional dentition was associated with income; older adults with higher income were less likely to have a non-functional dentition. Having a non-functional dentition was also related to being older, being female, being a current smoker and having one or more dental visit during the past year. Associations between smoking status and tooth loss were found in other studies (Aida et al., 2011; Kun-Jung et al., 2013; Warnakulasuriya et al., 2010). Associations between dental attendance and having non-functional dentition was reported also in a study from Sri Lanka (Perera and Ekanayake, 2011). There is an evidence that in Thailand, older people visit the dentist mainly when they experience symptoms such as pain or sensitivity (Dental Health Division, 2013b). Hence it is possible that dental visits lead to more tooth extractions in this age group.

8.4.1.2 Edentulousness

The unadjusted models of single level analyses revealed education and income gradients in edentulousness However, significant differences were found only between the highest and the lowest education and income groups. After adjusting for age and sex, a significant association was found only by income and the association between edentulousness and education became non-linear. Social gradients in edentulousness have been found in other developing countries, including Brazil

(Peres et al., 2013), and Mexico (Islas-Granillo et al., 2011). Individuals with higher incomes may be more likely to have conservative treatment (Klock, 1995; Yiengprugsawan et al., 2011a). Edentulousness was related with being older and not visiting the dentist during the past year. It is likely that individuals who were edentate were less likely to visit the dentist because they did not have teeth left.

8.4.2 Provincial level factors

The results showed between-area variations in tooth loss among those aged 60-74 years. However, after adjustment for provincial characteristics, only the prevalence of having a non-functional dentition varied significantly between provinces.

Urban/rural status was significantly associated with being edentate. This finding was similar to a previous Thai study (Yiengprugsawan et al., 2011a), which reported that lifetime urban dwellers were more likely to report having less than 20 teeth. One possible explanation is that individuals living in urban areas may have better access to the dental services, which may lead to more tooth extractions.

None of the other area-level measures were significantly associated with tooth loss. It could be that area-level characteristics need lag time to have an effect on oral health status. The provincial characteristics used in the study came from the same year of the survey data. In addition, the survey is based on cross-sectional data and does not include information about how long participants had lived in that province or area, therefore length of residence could not be taken into account.

8.5 Strengths and limitations

8.5.1 Strengths

The 7th Thai National Oral Health survey is not only the latest oral health survey in Thailand but also the only nationally representative oral health survey of the Thai population. The survey used a multistage random sampling method and standardised clinical oral health measures following WHO guidelines (World Health Organization, 1997). Also, the survey contains full range information at individual-level, including demographic and socio-economic position, and oral health-related behaviours. Furthermore, two age groups, i.e. middle-aged and older adults, were covered in the study. Middle-aged adults of working age are often ignored in health prevention and promotion programmes. In addition, data from this age group can be used to assess effects of oral health care provision. The older population is also very important as ageing populations are a global issue. Comparing the two age groups allowed the investigation of both age- and generation-related differences in oral health. For example, the older age group had a higher prevalence of oral diseases highlighting accumulation of disease through the life course, while the higher number of filled teeth in the middle-aged group suggests better access to dental health services.

This is not only the first study reporting social gradients in oral health among a representative sample of Thai adults, but also the first Thai study using multilevel modelling on clinical oral health outcomes. One advantage is that multilevel models allow assessing the associations between individual- and area-level characteristics and oral health status concurrently. Another advantage of the multilevel model is reporting variations in oral health between areas. Thai Oral Health Survey publications typically report oral health status only by regions. This study showed the

variations between provinces and used census data at provincial level which is smaller compared to regional level.

8.5.2 Limitations

There are several limitations of this study. Firstly, the data are cross-sectional in nature, and therefore cannot indicate the direction of the associations or any causal relationships. Secondly, the study was a secondary analysis that was necessarily based on the available data collected by the Bureau of Dental Health. Hence, there might be some information that has not been collected nor clearly described.

One limitation was the unclear reporting of the survey sampling method. The survey report only described sampling methods at the provincial- and area-level, but not how individual respondents were selected. This is also raising concerns in relation to the validity of the results on the prevalence of oral diseases. For instance, none of the individuals aged 35-44 were edentate.

Another limitation was the availability of survey measures. Regarding income, the results showed that income gradients were less clear compared to education gradients. This might be because personal monthly income might not reflect the actual socio-economic position of the individual especially among the older age group, who might be retired at age 60 and not have an income at that time. The other study from Thailand used household income and possession of durable goods in the household as a socio-economic measure for the older population (Srisilapanan et al., 2016). Regarding education, different categories of education had to be used for the two age groups because the older age group were more likely to have left school early compared to younger age group. (Office of the Education Council, 2017).

Moreover, some potential covariates were not available in the dataset, for example, information on diet or soft drink consumption, which are main risk factors of dental caries (Pitts et al., 2017).

Furthermore, although DMFT and CPI index were recommended measures by WHO, these have some limitations. There is a possibility to underestimate the number of DMFT and decayed teeth because of the restriction to detected proximal caries without use of radiographs. Secondly, although number filled teeth is one component of DMFT index, not every filling is due to decay. The indication of the decayed teeth in DMFT is an obvious cavity with soft caries. But when patients visit dental clinics, better dental caries diagnostic methods, such as radiography may be used and proximal caries or enamel caries which was not included in the decayed component might be filled and become filled component in the DMFT index.

The CPI index might underestimate the prevalence of periodontal disease as it only records representative teeth when there are more than two teeth present in the sextant (Bassani et al., 2006; Kingman and Albandar, 2002). Secondly, this index only shows current disease as it measures only pocket depth. Other studies mostly used both periodontal pocket depth and clinical attachment loss, which can measure both current disease and long-term effect of disease.

8.5.3 Recommendations for future research

As previously mentioned, this is the first study on social gradients in oral health status using data from the Thai National Oral Health Survey, so it needs to be replicated on the data of the previous or later surveys to understand trends over time. Following are some recommendations for future research.

Future studies could improve on this analysis by collecting a wider range of measures on socio-economic position, such as equivalised household income, which takes into account the number of household members, or durable goods possession, which might be more sensitive socio-economic measures than personal monthly income (Allin et al., 2009). For other potential factors that might be related to oral diseases, the following are oral health-related behaviour variables that should be considered in the future analyses: information on diet or sugar consumption, health insurance scheme, and the reason for dental visits (routine check-up or having any symptom).

The results of this thesis showed that socio-economic position at both individual- and area-level were associated with oral health status. Further analyses should examine interactions between measures of individual- and area-level socio-economic position. For example, individuals with low socio-economic position living in poorer areas might have better oral health status compared to those living in wealthier areas as a result of lower living costs, cost of dental treatment, and better neighbourhood relationships.

Regarding the use of multilevel models, the small number of areas might have led to inaccurate area-level standard errors. A larger number of provinces (area-level) in the next study/survey would increase the precision of the estimates (variance component and their standard errors).

Moreover, this study used cross-sectional data and did not consider how long participants were living in their area. Cohort studies should be considered to assess the associations between area-level socio-economic position and oral health by taking length of residence into account, and/or the association between changes in oral health status and changes in the living area.

8.6 Policy implications

Inequalities in health and oral health are important global health issues. The United Nations Development Programme (UNDP) included equality and health and well-being in the 2030 Agenda for Sustainable Development (United Nation, 2015). There is a large body of evidence on inequalities in health and oral health from many countries. However, evidence on the magnitude of inequality among the Thai population is still limited. The Thai government should monitor inequalities in oral health over time to inform policymaking. In addition, reducing oral health inequalities should be a priority.

The results show oral health status were not only associated with their own health behaviours but also associated with socio-economic position and area-level factors. This confirms that adopting only an individual approach to prevention and treatment cannot improve oral health and reduce oral health inequalities (Watt, 2012). To tackle oral health inequalities, both upstream and downstream approaches are important (Turrell et al., 1999; Watt, 2007). The World Health Organization also suggested “Health in All Policy” (HiAP) approach which aims to take into account of health on all public policy in order to integrate health into the policy and avoid policy that may harmful to health. This can improve health and health equality for the population (Koivosalu and Sparks, 2012). The review showed that public health policy interventions can be effective to reduce oral health in equalities. For example, according to the notification prescribing rate of excise tax B.E. 2560 (2017), the price of sugary drinks in Thailand will be increased according to the level of sugar added. Higher level of added sugar will lead to higher tax and price, helping to promote healthier choices.

As discussed earlier, unexpected reversed social gradients in DMFT were driven by the filled teeth component, which could be the results of overtreatment by dentists. There is evidence suggesting that dentist's reimbursement and patient's remuneration systems are both related to dentist's clinical activities (Brocklehurst et al., 2013; Chalkley and Listl, 2018). Universal coverage scheme (UCS) has been introduced since 2001 in order to reduce inequality in health and health service utilization in public sector. (Somkotra and Detsomboonrat, 2009). However, about half of all dentists in Thailand work in the private sector, around 40% work for hospitals under Ministry of Public Health, and the remaining 10% work in other public sectors, such as university, and Bangkok Metropolitan Administration[3]. In addition, most of the dentists are concentrated in Bangkok and other large urban area (Dental Health Division, 2013a) while most of the population under UCS are living in rural area. Therefore, the implementation of universal coverage scheme has not eliminated inequalities in oral health and service utilization. It is challenging to reduce inequalities in dental services utilization. Health policy makers should reconsider benefit packages of different health insurance schemes in order to improve unfairness of benefits.

This study provides evidence of variations in oral health status between provinces. Each province has its own problem and context. Therefore, it is important that the government should give authority to the local authorities, for example, the Provincial Public Health Office, in order to assess local problems and needs and to find appropriate interventions for their own area. The results also showed that the dentist per population ratio in Thailand ranged from 1: 4,162 to 1: 29,700. Uneven distribution of the dentists can lead to inequality in dental health services across the country. The

[3] Bangkok Metropolitan Administration is a local government of Bangkok. The administration's roles are to formulate and implement policies to manage Bangkok. The Public dental health services and policies in Bangkok are under Bangkok Metropolitan Administration not the Bureau of Dental Health, Department of Health.

government need to address this problem and find ways to encourage dentists to work in smaller city or remote areas. However, increasing the number of dentists in order to increase health care services might not prevent oral diseases. The results showed that residents in provinces that had more dentists were more likely to have periodontal disease. Therefore, oral health prevention and promotion need to be prioritised. In Thailand, there are village health volunteers who play important roles for primary health care especially in rural areas. They normally help healthcare professionals carry out basic health care for their neighbourhoods, including raising awareness of specific health issues and giving advice to all villagers (Kauffman and Myers, 1997). The Government should continue supporting the role of village health volunteers and integrate oral health promotion and prevention into the training.

Thailand has encountered an epidemiological transition in recent decades (Jongudomsuk et al., 2015). The main cause of death shifted to non-communicable diseases since 1999. Social development and economic growth resulted in major changes in population lifestyle. Populations with high socio-economic position were more susceptible to modern lifestyle-related NCDs. This may explain the evidence reported that non-communicable diseases which related to diet or lifestyle, for example, obesity, diabetes, cardiovascular diseases, and hypertension, were concentrated among higher socio-economic groups similar to the results showing high dental caries experience among high SEP groups (Aekplakorn et al., 2014; Kosulwat, 2006; Petcharoen et al., 2006; Thawornchaisit et al., 2013b). Oral health and oral health inequalities share common risk and determinants with general health, including behavioural risk and socio-economic determinants (Watt and Sheiham, 2012). Integrating oral health to general health and using common risk factor approach to improve health and health inequalities are more appropriate and effective compare to tackle oral health alone.

8.7 Research conclusion

This study aimed to assess whether there were socio-economic gradients in oral health among Thai adults using nationally representative survey data. The results added evidence on inequalities and socio-economic gradients in oral health status. There were reverse education and income gradients in DMFT, which were driven by the reverse gradients in the number of filled teeth. Some evidence on social gradient in decayed teeth, periodontal disease and tooth loss were also found. Multilevel analyses revealed variations in oral health status between provinces and the independent effect of provincial-level characteristics, especially the dentist per population ratio was related to filled teeth.

Further research together with action to tackle social inequalities in oral health among Thai adults at both individual- and area-levels are important to achieve better oral health for the whole population.

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Appendix

Appendix 1 Summary of multilevel study on oral health status

Table A-1 Multilevel study on dental caries

Author	study population	outcomes	Individual measures	contextual measures	Key finding
Clinical measures					
Tellez et al. (2006)	1,005 African-American caregivers nested in 27 low-income neighbourhood in Detroit, United States.	Number of untreated decayed tooth surfaces per adults, using ICDAS criteria	Age* Employment status* Perceived oral health* Oral hygiene status* Availability dental services* Total sugar intake* Emotional status*	SES score^{NS} (comprised of 3 factors; Social disadvantage, Housing infrastructure deficiency, and Wealth) Crime^{NS} Residential mobility^{NS} Churches* Grocery stores* Dentists^{NS}	The multilevel analyses showed that the number of decayed tooth surfaces was associated with all individual factors. Regarding contextual level factors, the average number of untreated decayed surfaces was negatively associated with the number of churches and positively associated with the number of grocery stores in neighbourhood. The variation of average caries level between areas was statistically significant in the null model and became non-significant after adjusting for contextual-level factors in fully adjusted model. Area level variance was 6.2 in the null model.
Bower et al. (2007)	632 Scottish adults, nested in 31 postcode sectors in Scotland (age 16 years and over)	one/more unsound teeth (unrestored dental caries)	age ^{NS} Sex ^{NS} Social class ^{NS} Household income* Education ^{NS}	Area deprivation ^{NS} Depcat 1-7= least-most deprived; composed of four factors; level of overcrowding in households, male unemployment, proportion of social class IV and V, and proportion of persons in private household without car	The results showed household income gradient in having unsound teeth; low household income was associated with unsound teeth. After adjusting for individual factors, none of association between area deprivation and prevalence of unsound teeth was found. Area level variance=0.757 (SE=0.285)

Author	study population	outcomes	Individual measures	contextual measures	Key finding
Celeste et al. (2009)	20,194 Brazilian adults nested in 328 municipalities (age 35-44 years old)	Number of teeth with untreated caries	Age Sex Urban/rural Time since last dental visit Household income	Municipal Gini*, Income Total homicide rate per 100,000 inhabitants Rate of dental procedures per 100,000 inhabitants Rate of dentists registered per 100,000 inhabitants Years of water fluoridation	Only effect Gini was reported. The number of decayed teeth was positively associated with Gini. The number of decayed teeth increased 1.28 (95%CI 1.18-1.42) times for each ten score of Gini increased. Variance Partition Coefficient=4.37% Cross-level interactions were tested. However, none of them was statistically significant.
Celeste et al. (2011)	12,154 Nationally representative Brazilian adults nested in 250 municipalities (age 35-44 years old)	Number of decayed teeth	Age* Sex* Urban/rural* Time since last dental visit* Household income*	Municipal income (year 2000)* Gini (year 2000)* Gini (year 1999)^{NS}	Bivariate analysis showed that number of decayed teeth was associated with all individual factors, municipal income and Gini from year 2000. Multilevel-logistic regression model showed that increasing in Gini in 2000 increased the mean number of decayed teeth (IRR=1.21; 95%CI 1.09-1.33). After adjusting for covariates, the association remained significant. Variance Partition Coefficient =3.6%

Author	study population	outcomes	Individual measures	contextual measures	Key finding
Choi and Lee (2011)	6,402 National representative Korean adults nested in 118 districts (aged 19 years and older)	Presence of dental caries experience (DMFT≥1)	Age* Sex* Monthly family income [NS] Smoking [NS] Tooth brushing frequency [NS] Regular dental visit*	Degree of Urbanization[NS] Density of service and medical facilities* Dependence on manufacturing industry*	Multilevel logistic regression showed that dental caries experience was associated with older age, being female and not having regular dental visit. Two contextual variables, including density of services and dependence on manufacturing industry, were negatively associated with dental caries experience. The variation between districted was statistically significant in the null model and became non-significant after adjusting for contextual-level factors in fully adjusted model. Area level variance was not reported
Self-reported measure					
Ardila et al. (2016)	6440 dentate adults in minority ethnic group, nested in 32 states and 1 Capital District in Colombia (age 18 years and more)	Presence of self-reported dental caries	Age* Gender[NS] Education* No flossing[NS] Tooth brushing <2 a day[NS] Changing toothbrush >2 months[NS] Last dental visit > 1 year* Unmet dental need*	GDP* HDI[NS] Unmet Basic Need Index[NS]	The multilevel analyses showed positive relationships of self-reported dental caries with age, education, last dental visit > 1 year and state GDP. There was a significant variation between area and the state level variance was 0.138 (SE=0.051)

[NS]= None of significant association was found; *= significant association was found

Table A-2 Multilevel study on periodontal disease

Author	study population	outcomes	Individual measures	contexual measures	Key finding
Bower et al. (2007)	632 Scottish adults, nested in 31 postcode sectors in Scotland (age 16 years and over)	One or more teeth had periodontal pocket depth ≥4 mm.	Age* Sex [NS] Social class [NS] Household income[NS] Education [NS]	area deprivation [NS] (Depcat 1-7= least-most deprived)	Age was the only one factor that was significantly associated with having periodontal pocket ≥4 mm (OR=1.31; 95%CI 1.10-1.55) Area level variance=3.017 (SE=0.966)
Celeste et al. (2011)	11,755 Nationally representative Brazilian adults nested in 250 municipalities (age 35-44 years old) (for gingivitis outcome n=7,766)	Presence of clinical attachment loss >8mm. Gingivitis (bleeding or having dental calculus)	Age* Sex* Urban/rural* Time since last dental visit* Household income*	Municipal income (year 2000)* Gini (year 2000)[NS] Gini (year 1999)[NS]	Bivariate analysis showed that both periodontal outcomes were associated with all individual factors. Regarding contextual-level, only gingivitis was associated with municipal income and Gini from year 1999. Multilevel-logistic regression model showed none of the association between periodontal diseases and Gini coefficient. Variance Partition Coefficient for CAL=33% Variance Partition Coefficient for gingivitis=21.9%
Vettore et al. (2013)	SBBrazil2010 4,594 Brazilian adults nested in 32 state Capitals and the Federal District (age 35-44 years old)	Moderate to severe periodontal disease (PD≥4 mm and CAL≥4 mm) Severe periodontal disease (PD≥4 mm and CAL≥6 mm)	Age* Sex* Skin colour* Family income* Year of schooling*	Gini index* HDI municipality[NS] %smokers* Integration of oral health care teams into Family Health Programme*	The multilevel analyses showed education and family income gradient in periodontal disease even adjusted for contextual level. For contextual-level, % smoker and level of integration associated with moderate to severe periodontal disease. GINI and level of integration were associated with severe periodontal disease.

Author	study population	outcomes	Individual measures	contexual measures	Key finding
Dalazen et al. (2016)	SBBrazil2010 3,926 dentate elderly (age 65-74 years old)	Dental calculus Shallow periodontal pocket (3-5mm) deep periodontal pocket (≥6 mm)	Sex* Skin colour* Family income^{NS} Education*	Gini index^{NS} Municipal HDI^{NS} Population coverage by Family Health Strategy*	The prevalence of poor periodontal conditions was higher for male, non-white elderly with low education. Only one contextual factor, Population coverage by FHS, was significant associated with having shallow and deep periodontal pocket. The area level variance was not reported
Sun et al. (2016)	20,204 adults aged 35-44 years old 9,666 adults aged 65-74 years old Nested in 30 provinces of Mainland China.	Number of teeth with periodontal pocket ≥4 mm Number of teeth with loss of attachment ≥4 mm	Sex* Ethnicity* Urban/rural* Education* Equivalized income* Toothbrushing frequency* Last dental visit* Smoking status*	Gini coefficient^{NS} GDP per capita* Public health expenditure* Dentist: population ratio* Dental therapist: population ratio^{NS} % Rural population % Minority group* Cigarette production^{NS} Tobacco crops^{NS} % Smoker*	For individual-level factors, the crude multilevel model showed that both outcomes were associated with almost all individual-level factors in both age groups For contextual-level factors, only the proportion of smoker was significantly associated with the number of teeth with periodontal pocket ≥4 mm among age group 65-74. The high number of teeth with loss of attachment ≥4 mm was significantly associated with high GDP per capita, public health expenditure, low dentist-to-population ratio and low proportion of minority ethnic groups in both age groups. Variance Partition Coefficient for periodontal pocket ≥4mm=3.3% Variance Partition Coefficient for loss of attachment ≥4 mm=4.8%

^{NS}= None of significant association was found; *= significant association was found

Table A-3 Multilevel study on tooth loss

Author	study population	outcomes	Individual measures	contexual measures	Key finding
Clinical measures					
Bower et al. (2007)	632 Scottish adults, nested in 31 postcode sectors in Scotland (age 16 years and over)	Number of functional teeth (Number of sound teeth including restores sound teeth)	Age* Sex [NS] Social class* Household income* Education*	area deprivation [NS] (Depcat 1-7= least-most deprived)	The results showed household income gradient in number of functional teeth; low household income, education and social class were associated with low number of sound teeth. Area deprivation was negatively associated with the number sound teeth. However, after adjusting for individual factors, the association became non-significant. Area level variance=3.017(SE=0.966)
Celeste et al. (2009)	22,169 Brazilian adults nested in 328 municipalities (age 35-44 years old)	Edentulousness	Age Sex Urban/rural Time since last dental visit Household income	Municipal Gini[NS], Income Total homicide rate per 100,000 inhabitants Rate of dental procedures per 100,000 inhabitants Rate of dentists registered per 100,000 inhabitants Years of water fluoridation	Only effect Gini was reported. Edentulousness was not associated with Gini. Variance Partition Coefficient = 9.07% Cross-level interactions were tested. However, none of them was statistically significant.
Moreira et al. (2010)	13,431 Brazilian adults nested in 250 municipalities in 27 stated from 5 regions in Brazil	The number of tooth loss	Age*, Sex*, Ethnic group[NS] Visit to the dentist* Time since the last dental visit* Location of last dental visit[NS] Reasons for last dental visit* Information on prevention* Years of schooling* Car ownership* Urban/rural[NS]	Number of dentist per 1,000 inhabitants* (regional level) Ratio of tooth extraction* (state level) Population size* (municipal level)	Multilevel model showed independent effect of contextual variables on tooth loss; high number of tooth loss was associated with low number of dentist, high ratio of tooth extraction and low population size. Regarding individual variables, the results showed education and wealth (measured by car ownership) gradients in tooth loss. Tooth loss also was associated with demographic and dental attendant characteristics. The area level variance was not reported

Author	study population	outcomes	Individual measures	contexual measures	Key finding
Celeste et al. (2011)	13,378 Nationally representative Brazilian adults nested in 250 municipalities (age 35-44 years old)	Edentulousness	Age* Sex* Urban/rural* Time since last dental visit* Household income*	Municipal income (year 2000)* Gini (year 2000) NS Gini (year 1999)NS	Bivariate analysis showed that being edentulous was associated with all individual factors and municipal income. Multilevel-logistic regression model showed none of the association between edentulousness and Gini coefficient. Variance Partition Coefficient =10.5%
Koltermann et al. (2011)	10,407 adults nested in 84 municipalities in State of Rio Grande do Sul (aged 35-44 years old)	Presence of Functional dentition (20 or more teeth remaining)	Age* Sex* Household income* Year of schooling* Visit dentist within 12 months* Information on prevention*	Mean municipal schooling* Period of fluoridated water* Rural/urban*	In fully adjusted model, functional dentition was associated with adults male with high education, high income and living in urban area with high mean municipal schooling and long period of floridated water. Level-2 variance was not reported.
Chalub et al. (2016)	2010 National Oral Health Survey 9,564 Brazilian adults nested in 177 municipalities (aged 35-44 years old)	Presence of functional dentition (4 different definition were used)	Gender* Age* Skin colour* Year of schooling* Monthly household income* Self-rated treatment need* Dental painNS Dental visit within previous 12 months*	Municipal HDI* Gini coefficientNS Presence of fluoridated water supply*	Multilevel model showed functional dentition was associated with adults with high education and income living in municipalities with high HDI and had fluoridated water supply. The associations were almost the same for all definitions of functional dentition. However, level variance for WHO functional dentition (≥20 teeth) and well-distributed teeth (≥10 teeth in each arch) became non-significant in fully adjusted model. There were significant variations between municipalities for functional dentition classified by esthetics and occlusion (level2 variance=0.026; SE=0.012)and functional dentition classified by esthetics, occlusion and periodontal status (level2 variance=0.032; SE=0.013).

Author	study population	outcomes	Individual measures	contexual measures	Key finding
Goulart and Vettore (2016)	6,366 adults nested in 27 state Capitals and the Federal District (age35-44 years old)	Severe tooth loss (<9 teeth remaining) Non-functional dentition (<21 teeth remaining)	Age* Sex* Ethnicity Family income* Years of schooling* Time since last dental visit*	Gini index variation* Gini index (year 1991)^{NS}	In fully adjusted model, severe tooth loss was associated with increasing of GINI index and adults with low education. Non-functional dentition was associated with increasing of GINI index and adults with low education and low income. In addition, There was education gradient in severe tooth loss and education and income gradients in non-functional dentition. Level 2 variance for severe tooth loss=0.104 (SE=0.055) Level 2 variance for non-functional dentition= 0.189 (SE=0.061)
Self-reported measures					
Turrell et al. (2007)	2,915 adults nested in 60 neighbourhoods in Adelaide, Australia (aged 43-57 years old)	self-reported number of missing teeth	Age Sex Education* Household income*	Index of Relative Socio-economic Disadvantage (IRSD)* based on 5 factors; %low-income family, %individuals with low education, occupancy of public housing, unemployment rate and the extent of workforce in unskilled occupations.	Fully adjusted model showed that the number of missing teeth was significantly associated with both education and income. In addition, socio-economically deprived neighbourhood reported higher level of missing Level 2 variance=2.58 (SE=0.637) However, the level 2 variance became non-significant in the fully adjusted model.
Sanders et al. (2008)	2,860 adults nested in 60 neighbourhoods in Adelaide, Australia (aged 43-57 years old)	Self-reported number of retained teeth	Age* Sex Education* Household income*	Index of Relative Socio-economic Disadvantage (IRSD)*	Fully adjusted model showed the number of retained teeth was negatively associated with age, education, household income and neighbourhood advantage. Level 2 variance was 0.65 (SE=0.27) Intra-class correlation=1.68%

Author	study population	outcomes	Individual measures	contexual measures	Key finding
Aida et al. (2011)	3,451 Japanese elders, aged 65 years and over nested in 79 local districts in 10 municipalities in Aichi prefecture	Self-reported less than 20 teeth remaining	Age*, Sex* Marital status^{NS} Education* Individual income^{NS} Smoking status* Mistrust* No-volunteering^{NS}	Gini coefficient* Rate of mistrust^{NS} Rate of non-volunteer^{NS} Community-level equivalent income^{NS}	After controlling for individual-level factors, the significant education gradient was found and GINI coefficient was positively associated with reporting less than 20 teeth remain (OR=1.54; 96% CI 1.14-2.14) Level 2 variance was 0.010 (SE=0.012)
Bernabé and Marcenes (2011)	386,629 adults living in 50 states of US. (aged 18 years and over)	Self-reported tooth loss (four categories; none, 1-5, 6/more, all teeth)	Age* Sex* Race* Marital status* Education* Household income* Time since last dental visit*	Gini coefficient* Median household income* %Receiving fluoridate water* Dentist: population ratio^{NS}	Tooth loss was associated with all individual-level factors and there were education and household income gradients in tooth loss. At contextual-level, tooth loss was significantly associated with Gini coefficient (OR=1.17; 95%CI 1.05-1.30), Median household income (OR=0.89; 95%CI 0.81-0.97), and Percent receiving fluoridated water (OR=1.02; 95%CI 1.00-1.04). Area level variance=0.025 (SE=0.005)
Barbato et al. (2015)	1,720 Adults nested in 60 census tracts of the southern Brazil (aged 29-59 years)	Presence of <10 teeth in at least one arch or edentate	Gender* Age* Skin colour* Per capita income* Education* Length of residence in the same location	Composite index of socio-economic position* based on mean income, average length of education, %household with access to treated water Period of fluoridated water*	Individuals with low education and low income living in poor area were more likely to reported <10 teeth in at least one arch or edentulous. Level 2 variance= 0.21; 95%CI 0.18-0.25
Ito et al. (2015)	79,563 Japanese elderly nested in 30 municipalities. (aged 65 years old or more)	Self-reported edentulous	Sex Age Marital status Education* Equvalent household income*	Community-level mean income* Density of dental clinics^{NS}	Fully adjusted model showed that edentulousness was associated with individuals who had low household income (OR=0.90; 95%CI 0.88-0.91), low education and lived in low income community (OR=0.53; 95%CI 0.33-0.85).

^{NS}= None of significant association was found; *= significant association was found

Appendix 2 Results of multilevel models

Table A-4 Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of DMFT among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
Up to primary		1		1	1	1	1	1
High school		1.06 (0.96-1.17)		1.05 (0.95-1.17)	1.07 (0.97-1.19)	1.09 (0.98-1.21)	1.04 (0.94-1.15)	1.04 (0.93-1.15)
Bachelor degree/higher		1.43 (1.25-1.64)***		1.41 (1.21-1.64)***	1.44 (1.24-1.68)***	1.40 (1.21-1.63)***	1.26 (1.08-1.46)**	1.25 (1.08-1.45)**
Income								
5000			1	1	1	1	1	1
5001-15000			1.07 (0.96-1.19)	1.00 (0.90-1.12)	1.00 (0.89-1.12)	1.05 (0.94-1.17)	1.05 (0.95-1.18)	1.05 (0.95-1.18)
>15000			1.22 (1.06-1.40)**	1.04 (0.89-1.21)	1.02 (0.87-1.18)	1.10 (0.95-1.28)	1.10 (0.95-1.28)	1.10 (0.95-1.28)
Age					1.02 (1.01-1.04)**	1.02 (1.01-1.04)*	1.02 (1.00-1.04)*	1.02 (1.00-1.04)*
Female						1.39 (1.27-1.53)***	1.33 (1.22-1.45)***	1.33 (1.21-1.45)***
Dental visit within the past year								
None							1	1
1 time							1.29 (1.16-1.44)***	1.29 (1.16-1.44)***
>1 time							1.58 (1.39-1.79)***	1.58 (1.40-1.80)***
Used Fluoride toothpaste								
No								1
Yes								0.94 (0.85-1.04)
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAI[3]								
GINI[4]								
Location type								
Rural								
Urban								
Bangkok								
Constant	5.67 (4.82-6.66)***	5.24 (4.44-6.17)***	5.29 (4.46-6.26)***	5.21 (4.38-6.19)***	5.18 (4.35-6.16)***	4.15 (3.45-4.99)***	3.81 (3.19-4.57)***	4.01 (3.30-4.88)***
Between province variance	0.11 (0.04)***	0.10 (0.04)***	0.10 (0.04)***	0.10 (0.04)***	0.10 (0.04)***	0.10 (0.04)***	0.09 (0.04)	0.09 (0.03)***
Overdispersion parameter	0.62	0.60	0.62	0.60	0.60	0.57	0.53	0.53

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-4 (cont.) Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of DMFT among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517)

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
Up to primary	1	1	1	1	1
High school	1.03 (0.93-1.14)	1.03 (0.93-1.14)	1.02 (0.92-1.13)	1.02 (0.92-1.13)	1.00 (0.90-1.11)
Bachelor degree/higher	1.25 (1.08-1.46)**	1.25 (1.08-1.45)**	1.24 (1.07-1.44)**	1.24 (1.07-1.44)**	1.17 (1.01-1.36)*
Income					
5000	1	1	1	1	1
5001-15000	1.05 (0.94-1.17)	1.05 (0.94-1.17)	1.06 (0.95-1.18)	1.06 (0.95-1.18)	1.05 (0.95-1.17)
>15000	1.10 (0.95-1.27)	1.10 (0.95-1.27)	1.11 (0.95-1.28)	1.11 (0.95-1.28)	1.09 (0.94-1.27)
Age	1.02 (1.00-1.04)*	1.02 (1.00-1.04)*	1.02 (1.00-1.04(*	1.02 (1.00-1.04)*	1.02 (1.00-1.03)*
Female	1.33 (1.21-1.45)***	1.33 (1.21-1.45)***	1.32 (1.21-1.45)***	1.32 (1.21-1.45)***	1.32 (1.21-1.44)***
Dental visit within the past year					
None	1	1	1	1	1
1 time	1.29 (1.16-1.44)***	1.29 (1.17-1.44)***	1.30- (1.17-1.44)***	1.30 (1.17-1.44)***	1.30 (1.17-1.44)***
>1 time	1.58 (1.39-1.80)***	1.58 (1.40-1.80)***	1.58 (1.39-1.80)***	1.59 (1.40-1.80)***	1.57 (1.39-1.78)***
Used Fluoride toothpaste					
No	1	1	1	1	1
Yes	0.94 (0.85-1.04)	0.94 (0.85-1.04)	0.94 (0.85-1.03)	0.94 (0.85-1.04)	0.94 (0.85-1.04)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	0.98 (0.97-1.00)*	1.00 (0.98-1.01)	0.99 (0.98-1.01)	0.99 (0.97-1.00)	0.99 (0.98-1.00)
Dentist : 100,000 population[2]		1.06 (0.99-1.13)	1.12 (1.06-1.19_***	1.08 (1.01-1.16)*	1.10 (1.02-1.19)*
HAI[3]			0.92 (0.88-0.97)**	0.93 (0.89-0.98)**	0.94 (0.89-0.98)*
GINI[4]				0.98 (0.97-1.00)	0.99 (0.97-1.01)
Location type					
Rural					1
Urban					1.22 (1.11-1.35)***
Bangkok					0.84 (0.50-1.43)
Constant	3.95 (3.29-4.75)***	3.94 (3.31-4.69)***	3.90 (3.33-4.57)***	3.90 (3.35-4.55)***	3.75 (3.21-4.39)***
Between province variance	0.07 (0.03)***	0.06 (0.02)***	0.03 (0.01)	0.03 (0.01)***	0.03 (0.01)***
Overdispersion parameter	0.53	0.53	0.53	0.53	0.52

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-5 Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of decayed teeth among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
Up to primary		1		1	1	1	1	1
High school		0.67 (0.54-0.83)***		0.69 (0.55-0.85)**	0.67 (0.54-0.84)***	0.67 (0.54-0.84)***	0.68 (0.54-.84)***	0.67 (0.54-0.84)***
Bachelor degree/higher		0.39 (0.28-0.54)***		0.44 (0.31-0.63)***	0.43 (0.31-0.61)***	0.43 (0.30-0.61)***	0.43 (0.31-0.61)***	0.42 (0.30-0.60)***
Income								
5000			1	1	1	1	1	1
5001-15000			0.75 (0.60-0.94)*	0.89 (0.71-1.13)	0.90 (0.71-1.13)	0.91 (0.71-1.15)	0.91 (0.72-1.15)	0.90 (0.71-1.14)
>15000			0.54 (0.40-0.73)***	0.73 (0.52-1.01)	0.75 (0.54-1.04)	0.76 (0.54-1.06)	0.76 (0.54-1.06)	0.75 (0.54-1.05)
Age					0.98 (0.94-1.01)	0.98 (0.94-1.01)	0.98 (0.94-1.01)	0.98 (0.94-1.01)
Female						1.06 (0.87-1.29)	1.06 (0.87-1.30)	1.06 (0.87-1.29)
Dental visit within the past year								
None							1	1
1 time							0.94 (0.74-1.18)	0.94 (0.74-1.19)
>1 time							0.98 (0.73-1.31)	0.99 (0.74-1.32)
Used Fluoride toothpaste								
No								1
Yes								0.86 (0.69-1.07)
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAI[3]								
GINI[4]								
Location type								
Rural								
Urban								
Bangkok								
Constant	0.76 (0.58-0.99)*	0.97 (0.73-1.30)	0.95 (0.69-1.30)	1.05 (0.76-1.44)	1.05 (0.76-1.44)	1.01 (0.72-1.42)	1.02 (0.73-1.44)	1.16 (0.79-1.70)
Between province variance	0.26 (0.11)***	0.29 (0.11)***	0.31 (0.12)***	0.30 (0.12)***	0.30 (0.12)***	0.30 (0.12)***	0.30 (0.12)***	0.30 (0.12)***
Overdispersion parameter	2.28	2.09	2.17	2.07	2.06	2.05	2.05	2.05

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-5 (cont.) Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of decayed teeth among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517).

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
Up to primary	1	1	1	1	1
High school	0.67 (0.54-0.84)***	0.67 (0.54-0.83)***	0.66 (0.53-0.82)***	0.66 (0.53-0.82)***	0.68 (0.54-0.85)**
Bachelor degree/higher	0.43 (0.30-0.60)***	0.43 (0.30-0.61)***	0.42 (0.29-0.59)***	0.42 (0.29-0.59)***	0.44 (0.31-0.64)***
Income					
5000	1	1	1	1	1
5001-15000	0.90 (0.71-1.14)	0.90 (0.71-1.13)	0.91 (0.72-1.16)	0.92 (0.72-1.16)	0.92 (0.73-1.17)
>15000	0.75 (0.53-1.05)	0.75 (0.53-1.05)	0.76 (0.54-1.07)	0.77 (0.55-1.08)	0.78 (0.55-1.09)
Age	0.98 (0.94-1.01)	0.98 (0.94-1.01)	0.98 (0.94-1.01)	0.98 (0.94-1.01)	0.98 (0.94-1.01)
Female	1.06 (0.87-1.29)	1.06 (0.86-1.29)	1.06 (0.87-1.29)	1.06 (0.87-1.30)	1.07 (0.88-1.31)
Dental visit within the past year					
None	1	1	1	1	1
1 time	0.94 (0.74-1.19)	0.94 (0.74-1.19)	0.94 (0.75-1.19)	0.95 (0.75-1.20)	0.95 (0.75-1.20)
>1 time	0.99 (0.74-1.32)	0.98 (0.74-1.31)	0.98 (0.74-1.31)	0.99 (0.74-1.32)	1.00 (0.75-1.33)
Used Fluoride toothpaste					
No	1	1	1	1	1
Yes	0.86 (0.69-1.07)	0.86 (0.69-1.08)	0.84 (0.68-1.07)	0.86 (0.69-1.08)	0.86 (0.69-1.07)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	0.99 (0.96-1.02)	1.01 (0.98-1.05)	1.00 (0.98-1.04)	1.00 (0.97-1.03)	1.00 (0.97-1.03)
Dentist : 100,000 population[2]		1.13 (1.00-1.29)*	1.24 (1.08-1.42)**	1.13 (0.97-1.32)	1.14 (0.97-1.34)
HAI[3]			0.88 (0.79-0.99)*	0.90 (0.81-1.00)	0.91 (0.82-1.02)
GINI[4]				0.96 (0.92-1.00)	0.96 (0.92-1.00)
Location type					
Rural					1
Urban					0.85 (0.67-1.07)
Bangkok					0.84 (0.27-2.60)
Constant	1.15 (0.78-1.69)	1.14 (0.79-1.64)	1.12 (0.79-1.58)	1.11 (0.80-1.55)	1.15 (0.82-1.61)
Between province variance	0.28 (0.11)***	0.22 (0.09)***	0.16 (0.07)***	0.13 (0.06)***	0.12 (0.06)***
Overdispersion parameter	2.04	2.04	2.05	2.05	2.04

***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-6 Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of decayed teeth among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
No education		1		1	1	1	1	1
Primary school		0.71 (0.51-0.99)*		0.71 (0.51-0.99)*	0.76 (0.54-1.06)	0.76 (0.54-1.06)	0.75 (0.54-1.05)	0.75 (0.54-1.05)
High school/higher		0.52 (0.34-0.79)**		0.55 (0.36-0.83)**	0.56 (0.37-0.85)**	0.56 (0.36-0.85)**	0.58 (0.38-0.89)*	0.58 (0.38-0.89)*
Income								
5000			1	1	1	1	1	1
5001-15000			0.99 (0.79-1.24)	1.01 (0.80-1.26)	1.06 (0.84-1.33)	1.06 (0.84-1.33)	1.07 (0.85-1.35)	1.07 (0.85-1.35)
>15000			0.71 (0.50-1.01)	0.77 (0.54-1.09)	0.80 (0.56-1.13)	0.80 (0.56-1.13)	0.81 (0.57-1.15)	0.81 (0.57-1.15)
Age					1.03 (1.01-1.06)**	1.03 (1.01-1.06)**	1.03 (11.01-1.05)**	1.03 (1.01-1.06)**
Female						0.98 (0.82-1.18)	1.02 (0.84-1.22)	1.01 (0.84-1.22)
Dental visit within the past year								
None							1	1
1 time							0.76 (0.60-0.97)*	0.76 (0.59-0.97)*
>1 time							0.73 (0.56-0.94)*	0.73 (0.57-0.94)*
Used Fluoride toothpaste								
No								1
Yes								0.93 (0.75-1.15)
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAI[3]								
GINI[4]								
Location type								
Rural								
Urban								
Bangkok								
Constant	1.55 (1.30-1.84)***	2.19 (1.55-3.10)***	1.59 (1.33-1.92)***	2.21 (1.56-3.14)***	2.06 (1.45-2.92)***	2.09 (1.43-3.05)***	2.25 (1.54-3.28)***	2.37 (1.57-3.57)***
Between province variance	0.10 (0.05)***	0.08 (0.04)***	0.10 (0.05)***	0.09 (0.04)***	0.08 (0.04)***	0.08 (0.04)***	0.07 (0.04)***	0.07 (0.04)***
Overdispersion parameter	1.74	1.72	1.73	1.71	1.69	1.69	1.66	1.66

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-6 (cont.) Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of decayed teeth among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 5	Model 6	Model 7
Individual-level					
Education					
No education	1	1	1	1	1
Primary school	0.75 (0.54-1.05)	0.76 (0.54-1.06)	0.76 (0.54-1.06)	0.76 (0.54-1.06)	0.79 (0.57-1.11)
High school/higher	0.58 (0.38-0.89)*	0.56 (0.38-0.89)*	0.59 (0.38-0.89)*	0.58 (0.38-0.89)*	0.69 (0.45-1.07)
Income					
5000	1	1	1	1	1
5001-15000	1.07 (0.85-1.35)	1.07 (0.85-1.34)	1.07 (0.85-1.35)	1.07 (0.85-1.34)	1.05 (0.83-1.32)
>15000	0.81 (0.57-1.15)	0.81 (0.57-1.15)	0.81 (0.57-1.15)	0.81 (0.57-1.15)	0.77 (0.54-1.09)
Age	1.03 (1.01-1.06)**	1.03 (1.01-1.06)**	1.03 (1.01-1.06)**	1.03 (1.01-1.05)**	1.03 (1.01-1.06)**
Female	1.01 (0.84-1.22)	1.01 (0.84-1.22)	1.01 (0.84-1.22)	1.01 (0.84-1.22)	1.02 (0.85-1.23)
Dental visit within the past year					
None	1	1	1	1	1
1 time	0.76 (0.59-0.97)*	0.76 (0.59-0.97)*	0.75 (0.59-0.97)*	0.75 (0.59-0.97)*	0.76 (0.59-0.97)*
>1 time	0.73 (0.57-0.94)*	0.73 (0.56-0.94)*	0.73 (0.56-0.94)*	0.73 (0.56-0.94)*	0.72 (0.56-0.93)*
Used Fluoride toothpaste					
No	1	1	1	1	1
Yes	0.93 (0.75-1.15)	0.93 (0.76-1.15)	0.93 (0.76-1.15)	0.93 (0.76-1.15)	0.92 (0.74-1.13)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	1.00 (0.99-1.02)	1.01 (0.99-1.03)	1.01 (0.99-1.03)	1.01 (0.98-1.03)	1.01 (0.99-1.03)
Dentist : 100,000 population[2]		1.04 (0.96-1.12)	1.03 (0.94-1.14)	1.02 (0.90-1.15)	1.03 (0.90-1.16)
HAI[3]			1.01 (0.93-1.09)	1.01 (0.93-1.10)	1.02 (0.94-1.11)
GINI[4]				0.99 (0.96-1.03)	0.99 (0.96-1.03)
Location type					
Rural					1
Urban					0.73 (0.59-0.90)**
Bangkok					0.73 (0.31-1.74)
Constant	2.37 (1.57-3.56)***	2.36 (1.57-3.55)***	2.37 (1.57-3.55)***	2.37 (1.58-3.56)***	2.55 (1.69-3.83)***
Between province variance	0.07 (0.04)***	0.07 (0.04)***	0.07 (0.04)***	0.07 (0.04)***	0.06 (0.03)***
Overdispersion parameter	1.66	1.66	1.66	1.66	1.64

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-7 Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of filled teeth among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
Up to primary		1		1	1	1	1	1
High school		2.00 (1.58-2.53)***		2.00 (1.57-2.54)***	2.00 (1.57-2.54)***	2.13 (1.69-2.71)***	1.95 (1.55-2.46)***	1.96 (1.55-2.47)***
Bachelor degree/higher		4.60 (3.40-6.24)***		4.24 (3.02-5.94)***	4.20 (2.99-5.90)***	4.22 (3.03-5.87)***	3.40 (2.46-4.69)***	3.41 (2.47-4.71)***
Income								
5000			1	1	1	1	1	1
5001-15000			1.29 (1.00-1.67)*	0.90 (0.70-1.17)	0.90 (0.70-1.17)	1.05 (0.81-1.35)	1.05 (0.82-1.35)	1.05 (0.82-1.35)
>15000			2.40 (1.75-3.29)***	1.22 (0.87-1.71)	1.24 (0.88-1.75)	1.59 (1.13-2.23)**	1.62 (1.17-2.26)**	1.63 (1.17-2.27)**
Age					0.98 (0.94-1.01)	0.97 (0.93-1.00)	0.96 (0.93-1.00)*	0.97 (0.93-1.00)*
Female						2.47 (2.00-3.04)***	2.33 (1.90-2.86)***	2.33 (1.90-2.86)***
Dental visit within the past year								
None							1	1
1 time							2.07 (1.64-2.50)***	2.07 (1.64-2.60)***
>1 time							2.53 (1.93-3.31)***	2.52 (1.92-3.30)***
Used Fluoride toothpaste								
No								1
Yes								1.05 (0.84-1.32)
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAI[3]								
GINI[4]								
Location type								
Rural								
Urban								
Bangkok								
Constant	1.35 (1.04-1.75)*	0.73 (0.57-0.94)*	0.98 (0.74-1.30)	0.75 (0.56-0.99)*	0.74 (0.56-0.98)*	0.37 (0.27-0.51)***	0.28 (0.20-0.38)***	0.27 (0.18-0.39)***
Between province variance	0.24 (0.10)***	0.16 (0.07)***	0.18 (0.08)***	0.16 (0.07)***	0.16 (0.07)***	0.18 (0.08)***	0.16 (0.07)***	0.16 (0.07)***
Overdispersion parameter	3.62	3.07	3.45	3.05	3.04	2.72	2.45	2.45

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-7 (cont.) Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of filled teeth among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n = 1,517).

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
Up to primary	1	1	1	1	1
High school	1.96 (1.56-2.47)***	1.94 (1.54-2.45)***	1.89 (1.50-2.37)***	1.89 (1.50-2.37)***	1.86 (1.48-2.35)***
Bachelor degree/higher	3.51 (2.54-4.85)***	3.49 (2.52-4.81)***	3.35 (2.43-4.61)***	3.35 (2.44-4.61)***	3.11 (2.26-4.29)***
Income					
5000	1	1	1	1	1
5001-15000	1.04 (0.81-1.33)	1.03 (0.81-1.32)	1.06 (0.83-1.35)	1.05 (0.83-1.34)	1.01 (0.79-1.29)
>15000	1.60 (1.15-2.22)**	1.59 (1.15-2.21)**	1.56 (1.13-2.16)**	1.55 (1.12-2.15)**	1.47 (1.07-2.03)*
Age	0.97 (0.93-1.00)	0.97 (0.93-1.00)	0.96 (0.93-1.00)*	0.96 (0.93-1.00)*	0.96 (0.93-1.00)*
Female	2.32 (1.89-2.85)***	2.32 (1.89-2.85)***	2.29 (1.87-2.82)***	2.29 (1.87-2.81)***	2.31 (1.88-2.83)***
Dental visit within the past year					
None	1	1	1	1	1
1 time	2.06 (1.64-2.60)***	2.06 (1.64-2.59)***	2.06 (1.64-2.59)***	2.06 (1.64-2.59)***	2.01 (1.60-2.52)***
>1 time	2.50 (1.91-3.28)***	2.51 (1.91-3.28)***	2.47 (1.89-3.23)***	2.48 (1.90-3.25)***	2.37 (1.81-3.10)***
Used Fluoride toothpaste					
No	1	1	1	1	1
Yes	1.05 (0.84-1.32)	1.05 (0.84-1.32)	1.05 (0.84-1.32)	1.05 (0.84-1.32)	1.08 (0.86-1.35)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	0.98 (0.96-0.99)**	0.99 (0.97-1.01)	0.98 (0.97-1.00)*	0.98 (0.97-1.00)*	0.98 (0.96-1.00)
Dentist : 100,000 population[2]		1.08 (0.99-1.17)	1.19 (1.11-1.27)***	1.17 (1.07-1.28)**	1.21 (1.08-1.34)**
HAI[3]			0.87 (0.82-0.92)***	0.87 (0.82-0.93)***	0.89 (0.83-0.95)**
GINI[4]				0.99 (0.97-1.02)	1.00 (0.97-1.02)
Location type					
Rural					1
Urban					1.62 (1.30-2.02)***
Bangkok					0.83 (0.42-1.66)
Constant	0.26 (0.18-0.37)***	0.26 (0.18-0.37)***	0.26 (0.19-0.36)***	0.26 (0.19-0.36)***	0.23 (0.16-0.32)***
Between province variance	0.10 (0.05)***	0.08 (0.04)***	0.01 (0.02) NS	0.01 (0.02)NS	0.02 (0.02)NS
Overdispersion parameter	2.45	2.45	2.45	2.45	2.37

***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-8 Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of filled teeth among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
No education		1		1	1	1	1	1
Primary school		5.86 (1.78-19.35)**		5.79 (1.75-19.13)**	5.42 (1.63-18.04)**	6.81 (2.05-11.66)**	5.91 (1.78-19.98)**	6.09 (1.80-20.58)**
High school/higher		35.1 (9.87-124.8)***		31.0 (8.62-111.3)***	30.1 (8.36-108.1)***	38.7 (10.9-137.6)***	27.8 (7.86-98.35)***	30.1 (8.38-108.2)***
Income								
5000			1	1	1	1	1	1
5001-15000			1.22 (0.73-2.04)	1.09 (0.67-1.77)	1.06 (0.65-1.73)	1.39 (0.85-2.25)	1.21 (0.75-1.96)	1.22 (0.76-1.98)
>15000			3.11 (1.57-6.14)**	1.56 (0.80-3.02)	1.53 (0.79-2.98)	2.06 (1.08-3.94)*	2.00 (1.06-3.77)*	1.93 (1.02-3.64)*
Age					0.98 (0.93-1.03)	1.00 (0.95-1.05)	0.97 (0.93-1.02)	0.98 (0.93-1.02)
Female						3.19 (2.13-4.78)***	2.91 (1.96-4.34)***	2.82 (1.89-4.20)***
Dental visit within the past year								
None							1	1
1 time							1.93 (1.20-3.12)**	1.96 (1.22-3.17)**
>1 time							3.12 (1.96-4.97)***	3.21 (2.01-5.11)***
Used Fluoride toothpaste								
No								1
Yes								0.65 (0.42-1.00)*
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAI[3]								
GINI								
Location type[4]								
Rural								
Urban								
Bangkok								
Constant	0.34 (0.21-0.55)***	0.04 (0.01-0.14)***	0.29 (0.18-0.45)***	0.04 (0.01-0.13)***	0.04 (0.01-0.14)***	0.01 (0.004-0.05)***	0.01 (0.003-0.05)***	0.02 (0.004-0.06)***
Between province variance	0.80 (0.34)***	0.65 (0.28)***	0.62 (0.27)***	0.61 (0.27)***	0.60 (0.26)***	0.55 (0.24)***	0.48 (0.22)***	0.47 (0.22)***
Overdispersion parameter	8.62	6.43	8.16	6.37	6.35	5.55	4.90	4.86

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-8 (cont.) Results of multilevel negative binomial regression models predicting Incidence Rate Ratio of filled teeth among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
No education	1	1	1	1	1
Primary school	6.04 (1.79-20.38)**	6.13 (1.83-20.59)**	6.19 (1.85-20.78)**	6.20 (1.85-20.80)**	4.52 (1.30-15.76)*
High school/higher	29.29 (8.16-105.1)***	30.17 (8.45-107.75)***	31.10 (8.72-111.01)***	31.1 (8.72-111.2)***	19.7 (5.39-72.07)***
Income					
5000	1	1	1	1	1
5001-15000	1.20 (0.75-1.94)	1.20 (0.74-1.93)	1.22 (0.76-1.96)	1.21 (0.75-1.96)	1.05 (0.66-1.68)
>15000	1.93 (1.02-3.64)*	1.98 (1.05-3.74)*	1.98 (1.05-3.74)*	1.97 (1.04-3.73)**	2.12 (1.16-3.88)*
Age	0.98 (0.93-1.03)	0.97 (0.93-1.02)	0.98 (0.93-1.03)	0.98 (0.93-1.03)	0.95 (0.91-1.00)
Female	2.79 (1.88-4.16)***	2.75 (1.85-4.09)***	2.74 (1.84-4.08)***	2.74 (1.84-4.07)***	2.78 (1.88-4.10)***
Dental visit within the past year					
None	1	1	1	1	1
1 time	1.95 (1.21-3.15)**	1.94 (1.21-3.12)**	1.92 (1.19-3.08)**	1.92 (1.20-3.09)**	1.83 (1.16-2.91)*
>1 time	3.17 (1.99-5.04)***	3.20 (2.01-5.09)***	3.25 (2.04-5.18)***	3.25 (2.04-5.18)***	3.45 (2.20-5.39)***
Used Fluoride toothpaste					
No	1	1	1	1	1
Yes	0.63 (0.41-0.97)*	0.63 (0.41-0.97)*	0.62 (0.40-0.95)*	0.62 (0.40-0.95)*	0.78 (0.51-1.18)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	0.97 (0.94-1.01)*	1.01 (0.96-1.06)	1.00 (0.96-1.05)	1.00 (0.96-1.05)	0.98 (0.94-1.03)
Dentist : 100,000 population[2]		1.18 (1.01-1.39)*	1.32 (1.09-1.60)**	1.30 (1.02-1.66)*	1.26 (0.98-1.62)
HAI[3]			0.87 (0.75-1.02)	0.87 (0.74-1.03)	0.85 (0.72-1.01)
GINI				0.99 (0.93-1.06)	0.99 (0.93-1.05)
Location type[4]					
Rural					1
Urban					5.35 (3.53-8.11)***
Bangkok					3.31 (0.70-15.7)
Constant	0.02 (0.004-0.07)***	0.02 (0.004-0.07)***	0.02 (0.005-0.07)***	0.02 (0.005-0.07)***	0.01 (0.002-0.03)***
Between province variance	0.40 (0.19)***	0.29 (0.15)***	0.21 (0.13)**	0.21 (0.13)**	0.19 (0.12)**
Overdispersion parameter	4.86	4.86	4.87	4.87	3.80

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-9 Results of multilevel logistic regression models predicting odds of having deep periodontal pocket (≥6mm.) among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n=1,517).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
Up to primary		1		1	1	1	1	1
High school		0.40 (0.22-0.73)**		0.37 (0.20-0.67)**	0.38 (0.21-0.69)**	0.36 (0.19-0.66)**	0.36 (0.19-0.65)**	0.35 (0.19-0.65)**
Bachelor degree/higher		0.54 (0.25-1.14)		0.48 (0.21-1.08)	0.49 (0.22-1.12)	0.51 (0.22-1.17)	0.50 (0.22-1.15)	0.50 (0.22-1.15)
Income								
5000			1	1	1	1	1	1
5001-15000			1.37 (0.78-2.42)	1.71 (0.95-3.07)	1.72 (0.96-3.09)	1.62 (0.90-2.92)	1.61 (0.89-2.92)	1.61 (0.89-2.91)
>15000			0.98 (0.45-2.12)	1.37 (0.59-3.18)	1.33 (0.57-3.12)	1.16 (0.49-2.76)	1.15 (0.49-2.73)	1.15 (0.48-2.72)
Age					1.03 (0.94-1.13)	1.04 (0.95-1.13)	1.04 (0.95-1.13)	1.04 (0.95-1.13)
Female						0.51 (0.31-0.84)**	0.46 (0.25-0.84)*	0.46 (0.25-0.84)*
Smoking status								
Non-smoker							1	1
Ex-smoker							0.82 (0.33-2.03)	0.82 (0.33-2.05)
Current-smoker							0.85 (0.43-1.67)	0.85 (0.43-1.68)
Brushing at least twice a day								
No								1
Yes								1.11 (0.46-2.70)
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAI[3]								
GINI[4]								
Location type								
Rural								
Urban								
Bangkok								
Constant	0.04 (0.03-0.06)***	0.06 (0.04-0.10)***	0.04 (0.02-0.06)***	0.05 (0.03-0.08)***	0.05 (0.03-0.08)***	0.07 (0.04-0.12)***	0.08 (0.04-0.15)***	0.07 (0.02-0.20)***
Between province variance	0.28 (0.18)**	0.28 (0.19)**	0.27 (0.18)**	0.25 (0.18)*	0.25 (0.18)*	0.26 (0.18)**	0.26 (0.18)**	0.26 (0.18)**
VPC (%)	7.84	7.84	7.58	7.06	7.06	7.32	7.32	7.32

***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-9 (cont.) Results of multilevel logistic regression models predicting odds of having deep periodontal pocket (≥6mm.) among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n=1,517).

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
Up to primary	1	1	1	1	1
High school	0.36 (0.19-0.65)**	0.35 (0.19-0.64)**	0.35 (0.19-0.64)**	0.34 (0.19-0.63)**	0.36 (0.19-0.66)**
Bachelor degree/higher	0.49 (0.21-1.13)	0.48 (0.21-1.11)	0.48 (0.21-1.10)	0.47 (0.20-1.08)	0.50 (0.21-1.19)
Income					
5000	1	1	1	1	1
5001-15000	1.68 (0.92-3.05)	1.65 (0.91-3.00)	1.66 (0.91-3.02)	1.71 (0.94-3.12)	1.72 (0.94-3.12)
>15000	1.21 (0.51-2.90)	1.20 (0.50-2.87)	1.20 (0.50-2.87)	1.26 (0.53-3.01)	1.28 (0.54-3.07)
Age	1.04 (0.95-1.13)	1.04 (0.95-1.13)	1.03 (0.94-1.13)	1.03 (0.94-1.13)	1.03 (0.95-1.13)
Female	0.46 (0.25-0.84)*	0.46 (0.25-0.84)*	0.46 (0.25-0.84)*	0.46 (0.26-0.85)*	0.47 (0.26-0.85)*
Smoking status					
Non-smoker	1	1	1	1	1
Ex-smoker	0.81 (0.32-2.01)	0.81 (0.32-2.01)	0.81 (0.32-2.01)	0.79 (0.32-1.98)	0.77 (0.31-1.92)
Current-smoker	0.85 (0.43-1.68)	0.86 (0.44-1.68)	0.86 (0.44-1.69)	0.86 (0.44-1.68)	0.85 (0.43-1.67)
Brushing at least twice a day					
No	1	1	1	1	1
Yes	1.14 (0.47-2.77)	1.14 (0.47-2.77)	1.14 (0.47-2.78)	1.11 (0.46-2.69)	1.10 (0.45-2.67)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	1.02 (098-1.05)	1.04 (0.99-1.08)	1.03 (0.99-1.08)	1.05 (1.00-1.10)*	1.06 (1.01-1.10)*
Dentist : 100,000 population[2]		1.10 (0.93-1.29)	1.12 (0.91-1.37)	1.26 (0.99-1.59)	1.31 (1.06-1.64)*
HAI[3]			0.98 (0.82-1.16)	0.95 (0.80-1.12)	0.99 (0.84-1.17)
GINI[4]				1.06 (0.99-1.14)	1.06 (1.00-1.13)
Location type					
Rural					1
Urban					0.91 (0.51-1.62)
Bangkok					0.30 (0.06-1.44)
Constant	0.07 (0.02-0.19)***	0.07 (0.02-0.19)***	0.07 (0.02-0.19)***	0.07 (0.02-0.19)***	0.08 (0.03-0.22***
Between province variance	0.23 (0.17)*	0.19 (0.16)*	0.19 (0.16)*	0.12 (0.13)	0.05 (0.11)
VPC (%)	6.53	5.46	5.46	3.52	1.50

***p<0.001 **p<0.01 *p<0.05 NS Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-10 Results of multilevel logistic regression models predicting odds of having deep periodontal pocket (≥6mm.) among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
No education		1		1	1	1	1	1
Primary school		0.94 (0.48-1.82)		0.94 (0.49-1.83)	0.82 (0.41-1.60)	0.79 (0.40-1.55)	0.78 (0.40-1.55)	0.78 (0.39-1.54)
High school/higher		0.63 (0.27-1.50)		0.70 (0.29-1.70)	0.64 (0.27-1.56)	0.61 (0.25-1.48)	0.60 (0.24-1.46)	0.61 (0.25-1.49)
Income								
5000			1	1	1	1	1	1
5001-15000			1.50 (0.97-2.32)	1.54 (0.99-2.39)	1.43 (0.92-2.24)	1.37 (0.87-2.15)	1.38 (0.87-2.18)	1.39 (0.88-2.19)
>15000			0.34 (0.12-0.96)*	0.37 (0.13-1.08)	0.34 (0.12-0.98)*	0.32 (0.11-0.93)*	0.31 (0.11-0.92)*	0.31 (0.10-0.90)*
Age					0.95 (0.90-1.00)*	0.95 (0.90-0.99)*	0.94 (0.90-0.99)*	0.94 (0.90-0.99)*
Female						0.81 (0.56-1.19)	0.73 (0.46-1.14)	0.73 (0.46-1.14)
Smoking status								
Non-smoker							1	1
Ex-smoker							0.77 (0.40-1.47)	0.74 (0.38-1.42)
Current-smoker							0.82 (0.46-1.45)	0.78 (0.44-1.40)
Brushing at least twice a day								
No								1
Yes								0.77 (0.49-1.22)
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAI[3]								
GINI[4]								
Location type								
Rural								
Urban								
Bangkok								
Constant	0.11 (0.07-0.18)***	0.13 (0.06-0.27)***	0.11 (0.07-0.17)***	0.12 (0.06-0.25)***	0.13 (0.06-0.29)***	0.17 (0.07-0.35)***	0.18 (0.08-0.42)***	0.22 (0.09-0.56)**
Between province variance	0.62 (0.32)***	0.63 (0.32)***	0.63 (0.23-1.74)***	0.64 (0.33)***	0.65 (0.33)***	0.65 (0.33)***	0.65 (0.33)***	0.64 (0.33)***
VPC (%)	15.86	16.07	16.07	16.28	16.50	16.50	16.50	16.28

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-10 (cont.) Results of multilevel logistic regression models predicting odds of having deep periodontal pocket (≥6mm.) among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
No education	1	1	1	1	1
Primary school	0.78 (0.40-1.54)	0.79 (0.40-1.56)	0.79 (0.40-1.56)	0.82 (0.42-1.62)	0.83 (0.42-1.66)
High school/higher	0.61 (0.25-1.50)	0.62 (0.25-1.51)	0.62 (0.25-1.52)	0.64 (0.26-1.56)	0.65 (0.26-1.65)
Income					
5000	1	1	1	1	1
5001-15000	1.41 (0.89-2.22)	1.40 (0.89-2.21)	1.40 (0.89-2.21)	1.43 (0.91-2.26)	1.43 (0.91-2.26)
>15000	0.31 (0.11-0.92)*	0.31 (0.11-0.91)*	0.31 (0.11-0.91)*	0.33 (0.11-0.98)*	0.33 (0.11-0.97)*
Age	0.94 (0.90-0.99)*	0.94 (0.90-0.99)*	0.94 (0.90-0.99)*	0.95 (0.90-0.99)*	0.95 (0.90-0.99)*
Female	0.73 (0.46-1.15)	0.73 (0.47-1.15)	0.73 (0.47-1.15)	0.74 (0.47-1.16)	0.74 (0.47-1.16)
Smoking status					
Non-smoker	1	1	1	1	1
Ex-smoker	0.74 (0.38-1.42)	0.74 (0.38-1.42)	0.74 (0.38-1.42)	0.74 (0.39-1.43)	0.73 (0.38-1.42)
Current-smoker	0.78 (0.44-1.39)	0.78 (0.44-1.39)	0.78 (0.44-1.39)	0.79 (0.44-1.40)	0.78 (0.44-1.40)
Brushing at least twice a day					
No	1	1	1	1	1
Yes	0.78 (0.49-1.23)	0.77 (0.49-1.23)	0.77 (0.49 -1.23)	0.77 (0.48-1.21)	0.77 (0.48-1.22)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	1.02 (0.98-1.06)	1.03 (0.97-1.10)	1.03 (0.97-1.09)	1.06 (1.00-1.11)*	1.06 (1.01-1.11)*
Dentist : 100,000 population[2]		1.06 (0.86-1.31)	1.09 (0.83-1.41)	1.36 (1.04-1.78)*	1.37 (1.03-1.82)*
HAI[3]			0.97 (0.78-1.21)	0.92 (0.77-1.10)	0.93 (0.77-1.12)
GINI[4]				1.11 (1.03-1.19)**	1.11 (1.03-1.19)**
Location type					
Rural					1
Urban					0.96 (0.62-1.49)
Bangkok					0.80 (0.12-5.29)
Constant	0.22 (0.09-0.55)**	0.22 (0.09-0.55)**	0.22 (0.09-0.55)**	0.21 (0.09-0.51)**	0.21 (0.09-0.53)**
Between province variance	0.60 (0.31)***	0.58 (0.31)***	0.58 (0.31)***	0.31 (0.20)***	0.31 (0.20)***
VPC (%)	15.42	14.99	14.99	8.61	8.61

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-11 Results of multilevel logistic regression models predicting odds of having less than 20 teeth (non-functional dentition) among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n=1,517).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5
Individual-level								
Education								
Up to primary		1		1	1	1	1	1
High school		0.70 (0.33-1.52)		0.72 (0.33-1.59)	0.81 (0.37-1.80)	0.82 (0.37-1.81)	0.78 (0.35-1.74)	0.78 (0.35-1.75)
Bachelor degree/higher		0.63 (0.21-1.93)		0.94 (0.28-3.15)	1.22 (0.35-4.18)	1.18 (0.34-4.04)	1.05 (0.30-3.68)	1.07 (0.30-3.74)
Income								
5000			1	1	1	1	1	1
5001-15000			1.10 (0.51-2.35)	1.15 (0.52-2.54)	1.14 (0.51-2.56)	1.17 (0.52-2.63)	1.16 (0.52-2.62)	1.16 (0.51-2.62)
>15000			0.29 (0.06-1.32)	0.29 (0.06-1.50)	0.24 (0.04-1.24)	0.25 (0.05-1.35)	0.25 (0.05-1.34)	0.26 (0.05-1.36)
Age					1.26 (1.09-1.45)**	1.25 (1.09-1.45)**	1.25 (1.08-1.44)**	1.25 (1.09-1.44)**
Female						1.30 (0.63-2.67)	1.23 (0.59-2.47)	1.50 (0.57-3.96)
Dental visit within the past year								
None							1	1
1 time							1.18 (0.50-2.81)	1.21 (0.51-2.87)
>1 time							1.71 (0.68-4.34)	1.75 (0.69-4.47)
Smoking status								
Non-smoker								1
Ex-smoker								1.49 (0.36-6.22)
Current-smoker								1.39 (0.43-4.45)
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAII								
GINI								
Location type								
Rural								
Urban								
Bangkok								
Constant	0.02 (0.01-0.03)***	0.02 (0.01-0.04)***	0.02 (0.01-0.04)***	0.02 (0.01-0.05)***	0.02 (0.01-0.04)***	0.02 (0.01-0.04)***	0.02 (0.01-0.04)***	0.01 (0.004-0.04)***
Between province variance	0.31 (0.30)^{NS}	0.32 (0.30)^{NS}	0.32 (0.30)^{NS}	0.32 (0.30)^{NS}	0.37 (0.33)*	0.37 (0.33)*	0.35 (0.32)^{NS}	0.35 (0.32)^{NS}
VPC (%)	8.61	8.86	8.86	8.86	10.11	10.11	9.62	9.62

***p<0.001 **p<0.01 *p<0.05 ^{NS} Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-11 (cont.) Results of multilevel logistic regression models predicting odds of having less than 20 teeth (non-functional dentition) among 35-44-year-old adults in the 7th Thai National Oral Health Survey (n=1,517).

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
Up to primary	1	1	1	1	1
High school	0.77 (0.35-1.72)	0.77 (0.34-1.72)	0.74 (0.33-1.66)	0.75 (0.33-1.68)	0.75 (0.33-1.69)
Bachelor degree/higher	1.10 (0.31-0.85)	1.09 (0.31-3.82)	1.04 (0.29-3.66)	1.04 (0.29-3.65)	1.03 (0.29-3.70)
Income					
5000	1	1	1	1	1
5001-15000	1.09 (0.48-2.46)	1.08 (0.47-2.44)	1.09 (0.48-2.48)	1.06 (0.47-2.41)	1.06 (0.47-2.40)
>15000	0.24 (0.04-1.26)	0.23 (0.04-1.25)	0.24 (0.04-1.26)	0.23 (0.04-1.22)	0.22 (0.04-1.21)
Age	1.25 (1.08-1.44)**	1.25 (1.08-1.44)**	1.25 (1.08-1.44)**	1.25 (1.08-1.44)**	1.25 (1.08-1.44)**
Female	1.49 (0.57-3.90)	1.49 (0.57-3.90)	1.50 (0.57-3.93)	1.46 (0.56-3.82)	1.43 (0.54-3.78)
Dental visit within the past year					
None	1	1	1	1	1
1 time	1.23 (0.52-2.93)	1.23 (0.52-2.93)	1.23 (0.52-2.92)	1.23 (0.52-2.92)	1.24 (0.52-2.94)
>1 time	1.74 (0.68-4.44)	1.74 (0.68-4.43)	1.71 (0.67-4.34)	1.73 (0.68-4.42)	1.69 (0.66-4.32)
Smoking status					
Non-smoker	1	1	1	1	1
Ex-smoker	1.57 (0.38-6.52)	1.57 (0.38-6.52)	1.59 (0.38-6.62)	1.59 (0.38-6.57)	1.56 (0.38-6.45)
Current-smoker	1.40 (0.44-4.44)	1.40 (0.44-4.44)	1.40 (0.44-4.44)	1.38 (0.43-4.38)	1.35 (0.42-4.34)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	0.97 (0.93-1.02)	0.98 (0.91-1.05)	0.97 (0.91-1.04)	0.96 (0.90-1.03)	0.97 (0.91-1.04)
Dentist : 100,000 population[2]		1.02 (0.82-1.28)	1.09 (0.83-1.43)	0.97 (0.69-1.36)	1.05 (0.74-1.49)
HAII			0.91 (0.73-1.14)	0.94 (0.75-1.17)	0.99 (0.78-1.25)
GINI				0.95 (0.86-1.05)	0.95 (0.87-1.05)
Location type					
Rural					1
Urban					1.41 (0.66-3.02)
Bangkok					0.31 (0.02-3.82)
Constant	0.01 (0.004-0.04)***	0.01 (0.004-0.04)***	0.01 (0.004-0.04)***	0.01 (0.004-0.04)***	0.01 (0.004-0.04)***
Between province variance	0.28 (0.30)^{NS}	0.29 (0.30)^{NS}	0.23 (0.28)^{NS}	0.19 (0.26)^{NS}	0.16 (0.24)^{NS}
VPC (%)	7.84	8.10	6.53	5.46	4.64

***p<0.001 **p<0.01 *p<0.05 ^{NS} Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-12 Results of multilevel logistic regression models predicting odds of having less than 20 teeth (non-functional dentition) among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
No education		1		1	1	1	1	1
Primary school		0.85 (0.53-1.35)		0.87 (0.55-1.39)	1.02 (0.63-1.63)	1.05 (0.65-1.69)	1.04 (0.65-1.68)	1.07 (0.66-1.73)
High school/higher		0.92 (0.52-1.61)		1.07 (0.60-1.90)	1.14 (0.64-2.06)	1.20 (0.66-2.16)	1.11 (0.61-2.02)	1.19 (0.65-2.16)
Income								
5000			1	1	1	1	1	1
5001-15000			0.80 (0.59-1.10)	0.79 (0.58-1.09)	0.87 (0.63-1.20)	0.90 (0.65-1.25)	0.86 (0.62-1.20)	0.86 (0.62-1.20)
>15000			0.63 (0.39-1.01)	0.60 (0.37-0.97)*	0.65 (0.40-1.06)	0.67 (0.41-1.10)	0.63 (0.38-1.03)	0.63 (0.38-1.04)
Age					1.07 (1.03-1.10)***	1.07 (1.03-1.10)***	1.07 (1.03-1.10)***	1.07 (1.04-1.10)***
Female						1.19 (0.92-1.53)	1.14 (0.88-1.48)	1.35 (0.99-1.84)
Dental visit within the past year								
None							1	1
1 time							1.51 (1.08-2.10)*	1.53 (1.10-2.13)*
>1 time							1.59 (1.14-2.24)**	1.64 (1.17-2.31)**
Smoking status								
Non-smoker								1
Ex-smoker								1.04 (0.68-1.60)
Current-smoker								1.75 (1.18-2.59)**
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAII								
GINI								
Location type								
Rural								
Urban								
Bangkok								
Constant	0.57 (0.46-0.71)***	0.66 (0.41-1.06)	0.62 (0.49-0.80)***	0.69 (0.43-1.13)	0.59 (0.36-0.97)*	0.52 (0.30-0.88)*	0.46 (0.27-0.80)**	0.37 (0.21-0.67)**
Between province variance	0.14 (0.07)***	0.14 (0.07)***	0.17 (0.09)***	0.18 (0.09)***	0.17 (0.09)***	0.18 (0.09)***	0.18 (0.09)***	0.19 (0.09)***
VPC (%)	4.08	4.08	4.91	5.19	4.91	5.19	5.19	5.46

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-12 (cont.) Results of multilevel logistic regression models predicting odds of having less than 20 teeth (non-functional dentition) among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
No education	1	1	1	1	1
Primary school	1.06 (0.65-1.71)	1.06 (0.66-1.72)	1.06 (0.66-1.71)	1.03 (0.64-1.66)	0.94 (0.58-1.53)
High school/higher	1.17 (0.64-2.13)	1.17 (0.64-2.14)	1.16 (0.64-2.12)	1.15 (0.63-2.09)	0.92 (0.50-1.70)
Income					
5000	1	1	1	1	1
5001-15000	0.85 (0.61-1.19)	0.85 (0.61-1.19)	0.87 (0.63-1.22)	0.87 (0.62-1.21)	0.87 (0.62-1.21)
>15000	0.62 (0.38-1.03)	0.62 (0.38-1.03)	0.64 (0.38-1.05)	0.62 (0.38-1.03)	0.66 (0.40-1.10)
Age	1.07 (1.04-1.10)***	1.07 (1.04-1.10)***	1.07 (1.04-1.11)***	1.07 (1.04-1.11)***	1.07 (1.03-1.10)***
Female	1.35 (0.99-1.83)	1.35 (0.99-1.83)	1.35 (0.99-1.83)	1.34 (0.98-1.82)	1.40 (1.03-1.91)*
Dental visit within the past year					
None	1	1	1	1	1
1 time	1.53 (1.10-2.13)*	1.52 (1.09-2.12)*	1.52 (1.09-2.13)*	1.52 (1.09-2.12)*	1.51 (1.08-2.11)*
>1 time	1.65 (1.17-2.32)**	1.64 (1.17-2.31)**	1.64 (1.16-2.30)**	1.63 (1.16-2.29)**	1.63 (1.16-2.31)**
Smoking status					
Non-smoker	1	1	1	1	1
Ex-smoker	1.05 (0.68-1.61)	1.05 (0.68-1.61)	1.04 (0.67-1.59)	1.03 (0.67-1.58)	1.12 (0.73-1.74)
Current-smoker	1.75 (1.18-2.60)**	1.76 (1.18-2.60)**	1.75 (1.18-2.59)**	1.74 (1.17-2.57)**	1.91 (1.28-2.85)**
Contextual-level					
Provincial Poverty Headcount Ratio[1]	0.99 (0.96-1.01)	0.99 (0.96-1.03)	0.99 (0.06-1.02)	0.98 (0.95-1.01)	0.99 (0.96-1.02)
Dentist : 100,000 population[2]		1.03 (0.92-1.16)	1.13 (0.99-1..29)	1.04 (0.89-1.22)	1.09 (0.94-1.28)
HAII			0.89 (0.80-0.99)*	0.91 (0.82-1.01)	0.93 (0.84-1.02)
GINI				0.97 (0.93-1.01)	0.97 (0.93-1.01)
Location type					
Rural					1
Urban					1.87 (1.41-2.50)***
Bangkok					0.59 (0.21-1.66)
Constant	0.38 (0.21-0.68)**	0.38 (0.21-0.67)**	0.38 (0.21-0.66)***	0.39 (0.22-0.68)**	0.35 (0.20-0.61)***
Between province variance	0.18 (0.09)***	0.17 (0.09)***	0.12 (0.07)***	0.09 (0.06)**	0.07 (0.05)*
VPC (%)	5.19	4.91	3.52	2.66	2.08

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-13 Results of multilevel logistic regression models predicting odds of being edentulous among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,264).

Variable	Model 1	Model 2	Model 3	Model 4	Model 5a	Model 5b	Model 5c	Model 5d
Individual-level								
Education								
No education		1		1	1	1	1	1
Primary school		1.28 (0.53-3.06)		1.34 (0.56-3.23)	1.76 (0.72-4.29)	1.77 (0.73-2.33)	1.80 (0.73-4.41)	1.83 (0.75-4.49)
High school/higher		1.07 (0.37-3.05)		1.38 (0.47-4.03)	1.58 (0.54-4.69)	1.60 (0.54-4.75)	1.71 (0.57-5.12)	1.80 (0.60-5.44)
Income								
5000			1	1	1	1	1	1
5001-15000			0.76 (0.44-1.32)	0.75 (0.43-1.31)	0.89 (0.51-1.57)	0.90 (0.51-1.59)	0.92 (0.52-1.62)	0.92 (0.52-1.64)
>15000			0.30 (0.09-0.98)*	0.29 (0.09-0.97)*	0.35 (0.10-1.19)	0.35 (0.10-1.19)	0.37 (0.11-1.27)	0.37 (0.11-1.28)
Age					1.12 (1.06-1.18)***	1.12 (1.06-1.18)***	1.12 (1.06-1.18)***	1.12 (1.06-1.18)***
Female						1.04 (0.67-1.62)	1.10 (0.70-1.71)	1.23 (0.72-2.10)
Dental visit within the past year								
None							1	1
1 time							0.28 (0.11-0.70)**	0.28 (0.11-0.70)**
>1 time							0.86 (0.48-1.55)	0.88 (0.49-1.60)
Smoking status								
Non-smoker								1
Ex-smoker								0.98 (0.45-2.12)
Current-smoker								1.50 (0.78-2.87)
Contextual-level								
Provincial Poverty Headcount Ratio[1]								
Dentist : 100,000 population[2]								
HAII								
GINI								
Location type								
Rural								
Urban								
Bangkok								
Constant	0.07 (0.05-0.10)***	0.06 (0.02-0.14)***	0.08 (0.06-0.11)***	0.06 (0.03-0.15)***	0.04 (0.02-0.10)***	0.04 (0.02-0.11)***	0.05 (0.02-0.12)***	0.04 (0.01-0.11)***
Between province variance	0.14(0.12)^{NS}	0.14 (0.13)*	0.19 (0.15)*	0.19 (0.15)*	0.17 (0.14)*	0.17 (0.14)*	0.19 (0.15)*	0.19 (0.15)*
VPC (%)	4.08	4.08	5.46	5.46	4.91	4.91	5.46	5.46

***p<0.001 **p<0.01 *p<0.05 ^{NS} Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-13 (con.) Results of multilevel logistic regression models predicting odds of being edentulous among 60-74-year-old adults in the 7th Thai National Oral Health Survey (n = 1,143).

Variable	Model 6a	Model 6b	Model 6c	Model 6d	Model 7
Individual-level					
Education					
No education	1	1	1	1	1
Primary school	1.77 (0.72-4.32)	1.85 (0.76-4.54)	1.86 (0.76-4.54)	1.83 (0.75-4.47)	1.74 (0.71-4.29)
High school/higher	1.72 (0.57-5.16)	1.76 (0.59-5.29)	1.83 (0.61-5.46)	1.82 (0.61-5.42)	1.67 (0.54-5.14)
Income					
5000	1	1	1	1	1
5001-15000	0.90 (0.51-1.59)	0.89 (0.50-1.58)	0.90 (0.51-1.59)	0.89 (0.50-1.57)	0.87 (0.49-1.54)
>15000	0.36 (0.11-1.25)	0.38 (0.11-1.31)	0.39 (0.11-1.34)	0.38 (0.11-1.31)	0.38 (0.11-1.33)
Age	1.12 (1.06-1.18)***	1.11 (1.06-1.18)***	1.12 (1.06-1.18)***	1.12 (1.06-1.18)***	1.12 (1.06-1.18)***
Female	1.21 (0.71-2.06)	1.22 (0.72-2.07)	1.20 (0.71-2.04)	1.20 (0.71-2.03)	1.20 (0.71-2.05)
Dental visit within the past year					
None	1	1	1	1	1
1 time	0.28 (0.11-0.70)**	0.27 (0.11-0.68)**	0.27 (0.11-0.69)**	0.27 (0.11-0.69)**	0.27 (0.11-0.69)**
>1 time	0.90 (0.50-1.61)	0.88 (0.49-1.59)	0.88 (0.49-1.59)	0.88 (0.49-1.59)	0.88 (0.49-1.58)
Smoking status					
Non-smoker	1	1	1	1	1
Ex-smoker	0.96 (0.45-2.08)	0.99 (0.46-2.14)	0.94 (0.43-2.02)	0.93 (0.43-2.01)	0.98 (0.45-2.14)
Current-smoker	1.51 (0.79-2.90)	1.53 (0.80-1.92)	1.47 (0.77-2.81)	1.46 (0.77-2.80)	1.55 (0.81-2.98)
Contextual-level					
Provincial Poverty Headcount Ratio[1]	0.98 (0.05-1.00)	1.00 (0.96-1.04)	1.00 (0.96-1.04)	1.00 (0.96-1.03)	1.00 (0.96-1.04)
Dentist : 100,000 population[2]		1.13 (0.99-1.28)	1.23 (1.05-1.44)*	1.19 (0.98-1.45)	1.22 (1.00-1.50)
HAII			0.90 (0.80-1.01)	0.91 (0.80-1.03)	0.92 (0.81-1.05)
GINI				0.99 (0.94-1.04)	0.99 (0.94-1.04)
Location type					
Rural					1
Urban					1.64 (1.00-2.67)*
Bangkok					0.78 (0.23-2.61)
Constant	0.04 (0.01-0.12)***	0.04 (0.01-0.11)***	0.04 (0.01-0.11)***	0.04 (0.02-0.11)***	0.04 (0.01-0.10)***
Between province variance	0.12 (0.12)[NS]	0.07 (0.10)[NS]	0.02 (0.08)[NS]	0.02 (0.08)[NS]	0.1 (0.08)
VPC (%)	3.52	2.08	0.60	0.60	0.30

***p<0.001 **p<0.01 *p<0.05 [NS] Random effect not statistically significant

[1] unit = one percent of population under the poverty line [2] unit = one dentist per 100,000 population

[3] unit = 0.01 score of Human Achievement Index [4] unit = 1 percent of GINI index

Table A-14 The association between education and urban/rural among 35-44-year-old adults (n=1,517) and 60-74-year-old adults (n=1,143).

	Rural	Urban	Bangkok	p-value
		% (95% CI)		
35-44 years				
Up to primary school	60.4 (56.8-63.8)	31.6 (25.8-38.0)	28.1 (20.7-37.0)	**<0.001**
High school	33.0 (29.7-36.5)	39.8 (33.5-46.4)	53.2 (44.2-62.0)	
Bachelor's degree	6.7 (5.3-8.4)	28.6 (22.7-35.4)	118.7 (12.9-26.3)	
60-74 years				
No education	11.0 (8.4-14.2)	3.7 (1.9-7.2)	2.6 (0.8-7.9)	**<0.001**
primary school	82.1(78.4-85.3)	72.3 (64.8-78.7)	61.8 (51.9-70.7)	
High school/ higher	7.0 (5.0-9.6)	24.0 (17.8-31.5)	35.6 (26.9-45.4)	

Table A-15 The association between DMFT and its component and type of dental practice in the last year dental visit among 35-44-year-old adults (n=571) and 60-74-year-old adults (n=403)

	DMFT	Decayed teeth		Filled teeth	
	35-44 years	35-44 years	60-74 years	35-44 years	60-74 years
	teeth/person (SD)				
Public facilities	7.1 (5.1)	0.7 (1.7)	1.2 (1.9)	2.4 (3.2)	0.8 (1.9)
Private facilities	8.5 (4.3)	0.6 (1.0)	0.63(1.2)	4.5 (3.4)	1.6 (2.9)
P-value	**0.0055**	0.2282	0.0748	0.0698	**<0.001**

Table A-16 The associations between individual-level socio-economic position, urban/rural and type of dental practice used among 35-44-year-old adults (n=571).

		Public facilities	Private facilities	p-value
Education	Up to primary school	84.5 (77.3-89.8)	15.5 (10.2-22.7)	**0.0103**
	High school	67.9 (57.4-76.8)	32.1 (23.2-42.6)	
	Bachelor's degree/higher	63.5 (49.0-75.9)	36.5 (24.1-51.0)	
Income	0-5,000 THB	87.5 (79.3-92.8)	12.5 (7.2-20.7)	**0.0062**
	5,001-15,000 THB	67.4 (57.8-75.7)	32.6 (24.3-42.2)	
	15,001 or more	65.4 (50.8-77.6)	34.6 (22.4-49.2)	
Urban/rural	Rural	85.6 (80.9-89.2)	14.5 (10.8-19.1)	**<0.0012**
	Urban	62.8 (52.3-72.3)	37.2 (27.8-47.7)	
	Bangkok	65.6 (51.4-77.5)	34.4 (22.5-48.6)	

Table A-17 The associations between individual-level socio-economic position, urban/rural and type of dental practice used among 60-74-year-old adults (n=403).

		Public facilities	Private facilities	p-value
Education	No education	82.6 (49.8-95.8)	17.4 (4.2-50.1)	0.9927
	Primary school	81.2 (74.3-86.6)	18.8 (13.5-25.7)	
	High school	81.8 (63.1-92.2)	18.3 (7.9-24.9)	
Income	0-5,000 THB	85.0 (78.0-90.1)	15.0 (9.9-22.1)	0.1582
	5,001-15,000 THB	73.7 (57.8-85.1)	26.3 (14.9-42.2)	
	15,001 or more	81.5 (65.8-91.0)	18.5 (9.0-34.2)	
Urban/rural	Rural	90.1 (84.8-93.7)	9.9 (6.3-15.2)	**0.0011**
	Urban	75.2 (63.2-84.2)	24.8 (15.8-36.8)	
	Bangkok	64.9 (50-8-76.8)	35.1 (23.2-449.2)	