FUNCTIONAL CAPACITY AS A DETERMINANT OF ORAL HEALTH - AN 11-YEAR LONGITUDINAL STUDY

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FUNCTIONAL CAPACITY AS A DETERMINANT OF ORAL HEALTH - AN 11-YEAR LONGITUDINAL STUDY

This study aimed to determine whether functional capacity is a predictor of oral health, particularly of decayed and deepened periodontal pockets ≥ 4mm in a longitudinal setting.

The study included 1225 subjects aged 30 years and over at baseline who participated in clinical oral examination and answered questions about functional ability in both the Health 2000 and Health 2011 Surveys in Finland. Functional capacity was measured through the interview on Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL), based on Katz Index of ADL, Lawton & Brody IADL scale and Organisation for Economic Co-operation and Development (OECD) recommendations. Oral health was assessed by clinical examination of decayed teeth and teeth with deepened periodontal pockets ≥ 4mm. The difference in the average number of decayed teeth and teeth with deepened periodontal pockets ≥ 4mm among subjects according to their functional capacity was analyzed using Mann Whitney U test. Association of IADL with decayed teeth and teeth with deepened periodontal pockets ≥ 4mm was assessed through Poisson regression analysis.

According to Mann Whitney U test, no significant differences were seen in the average number of decayed teeth and teeth with deepened periodontal pockets ≥ 4mm according to the difficulty in functional ability using ADL. Though, only significant difference was observed in number of decayed teeth among participants who had any difficulty in cutting toenails as compared to participants who experienced no difficulty. In addition, there were significant differences in the average number of decayed teeth and teeth with deepened periodontal pockets ≥ 4mm according to the functional ability of subjects, by using some tasks of IADL scale. When analyzed by Poisson regression analysis, significant differences in the number of decayed teeth and the number of teeth with deepened periodontal pockets ≥ 4mm were seen among participants according to their functional capacity using IADL.

The results of this study conclude that functional capacity is a determinant of oral health. Moreover, the inability to perform tasks related to IADL is an important indicator for the risk of future decayed teeth and teeth with deepened periodontal pockets ≥ 4mm. However, further longitudinal studies are needed with a large sample size to explore the association of functional capacity with oral health among adult and elderly Finnish population.

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I dedicate this thesis to my father Rehan ul Haq, whose loving memories will always be with me forever.

Yamna Rehman
8.01.2019

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ABBREVIATIONS

AD-Alzheimer's Disease

ADL -Activities of Daily Living

CPI- Community Periodontal Index

GBD-Global Burden of Disease Data

IADL**-** Instrumental Activities of Daily Living

ICF- WHO International Classification of Functioning, Disability, and Health Model

MMP- Matrix Metalloproteinases

MMSE- Mini Mental State Examination

PD-Parkinson's Disease

POGO-Project on Government Oversight

SUFUCA -Supporting the Functional Capacity of Older people with Skill and Quality

WHO -World Health Organization

1 INTRODUCTION

Oral health is vital for maintaining general health and quality of life. It can be defined as "A state of being free from mouth and facial pain, oral and throat cancer, oral infection and sores, periodontal (gum) disease, caries, tooth loss, and other diseases and disorders which can affect and in turn limit the individual's oral functions such as biting, chewing, smiling, speaking, and affect psychosocial wellbeing" (World Health Organization WHO 2012).

Various risk factors affect oral health and cause oral diseases. One of these risk factors can be poor functional capacity. Functional capacity is defined as "a person's ability to deal with daily-life activities" and can have an enormous impact on the quality of life of an individual. Daily activities of living change throughout the life span of a person; children, adults, and the elderly, each of them have a unique set of activities which are necessary to maintain their independence (Avlund *et al*. 2001). Therefore, it is measured most appropriately according to age-specific life-cycle tasks that a person may need to perform (Encyclopedia of Public Health 2002).

Functional capacity in general consists of three different domains i.e. physical, psychological and social domains. Physical functional capacity assesses abilities to perform Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL). Psychological functional capacity includes personality, moods, memory, learning, abilities to perform mental activities and others. Social functional capacity includes different tasks and roles that are specific to a person's age, gender and social and cultural background (Supporting the Functional Capacity of Older people with Skill and Quality SUFUCA 2017).

Poor physical functional capacity which can be defined as "difficulty experienced in performing daily life activities i.e. ADL and IADL"; can affect a person's ability to maintain good oral hygiene and limit their capability to access necessary dental treatment. Therefore, it is likely that disabled persons or persons with poor functional ability are at increased risk of oral diseases (Avlund *et al.* 2001).

During recent years, age structure of the population is rapidly changing. Due to an increase in life expectancy, more people are now living to older ages and the older population is getting older (Razak *et al*. 2014). As people are aging, the dental transition has been seen among developed countries in recent decades i.e. more people are retaining natural teeth in old age which has decreased the proportion of edentulous people steadily (Thomson & Ma 2014).

However, the functional capacity decreases with old age, therefore more studies are needed to evaluate this relationship between functional capacity and oral health to identify the at-risk groups of population.

2 LITERATURE REVIEW

2.1 Oral health

2.1.1 Distribution of oral diseases

2.1.1.1 Global burden

Despite the advanced prevention and treatment options for various oral health disorders, at present, oral health issues are still highly prevalent around the globe. The severity of these diseases differs in different parts of the world and within the same country or region. Due to increased consumption of sugars and inadequate exposure to fluoride, along with changes in socio-behavioral and environmental factors, oral diseases are becoming more of an issue (WHO 2018).

Studies suggest that the cumulative burden of oral conditions has increased dramatically during 1990-2015. One of the reasons for this may be the demographic changes which includes population growth and aging. It has been estimated that the number of people with untreated oral conditions was approximately 2.5 billion in 1990 which rose to 3.5 billion in 2015. Total disability-adjusted life years DALY's due to oral conditions have increased by 64% throughout the world. Nearly half of the world's population is suffering from disability due to oral conditions. The most prevalent oral health condition throughout the world in 2015 was untreated caries in permanent teeth which affected 2.5 billion people worldwide. Other prominent oral health diseases were severe periodontal disease which affected 538 million people and total tooth loss which affected 276 million people throughout the world. The total number of incident cases related to caries in permanent and in deciduous teeth, severe chronic periodontitis and tooth loss in 2015 were 616 million globally (Kassebaum *et al*. 2017).

According to a study by Listl *et al*. (2015), direct treatment costs due to dental diseases worldwide were $298 billion in the year 2010, which corresponded to 4.6% of global health expenditure. The indirect expenditure which occurred due to productivity loss was $144 billion globally. The direct and indirect cost of oral diseases made an economic burden of $442 billion only in 2010. As the population is rapidly growing and aging, the number of cases and treatment cost is expected to increase, hence posing a very serious public health challenge to policymakers (Listl *et al*. 2015).

2.1.1.2 Burden in Finland

In Finland, oral health status is strongly dependent upon socioeconomic status and level of education. People who are less educated are least active in oral self-care and thus have the highest number of oral diseases. Overall, these people constitute a high-risk group for poor oral health. According to gender, women are more active in oral self-care and visiting the dentist than men. According to the region, southern Finland is better in terms of oral health than northern and eastern Finland, which have the highest number of edentulous (no teeth) people. People living in northern and eastern Finland are more affected by edentulism and have comparatively fewer teeth than other parts of the country (Suominen-Taipale *et al.* 2008).

According to the Health 2000 Survey, the overall coverage of dental care is high in Finland. Most of the adults visit dentists regularly however, preventive treatment is almost infrequent. Despite good dental care coverage, the most common type of oral diseases among them is periodontitis. It is estimated that two out of every three dentate subjects in Finland are affected by deepened periodontal pockets (≥ 4mm). The overall percentage of dentate patients affected by decayed teeth and periodontal pockets were 31% and 64% respectively (Suominen-Taipale *et al.* 2008).

The overall oral health status of the Finnish population has improved from 1980 through 2000, these changes are more prominent in young adults and well-educated groups of the population. There has been a prominent decrease in the prevalence of edentulousness and caries among Finns. People are now more aware of the use of dental services and oral self-care than 20 years ago. Despite these improvements, more improvement is needed for oral health care especially in men (Suominen-Taipale *et al*. 2008).

2.1.2 Determinants of oral health

2.1.2.1 Individual factors

2.1.2.1.1 Aging

The population around the world is rapidly aging and today aging has become one of the most important social transformations in the twenty-first century. According to 2017 statistics, there are approximately 962 million people who are aged 60 or over in the world. It comprises of 13% of the global population. According to the continent, Europe has the highest

proportion (25%) of people who are aged 60 and above. It has been estimated that in 2030 the number of old people in the world will be 1.4 billion which will keep rising to 2.1 billion in 2050 and 3.1 billion in 2100 (United Nations 2017). The reasons for this demographic transformation are increased life expectancy due to better living conditions, a decrease in birth rate and a decrease in death rate (Boulding 2003). Also, now people are retaining their natural teeth late in life and edentulism is decreasing substantially. The reason is an advancement in oral health care which includes advancement in the prevention of oral diseases, and the availability of better treatment options (Müller *et al*. 2007).

Maintaining good oral hygiene in old age is important not only to maintain and improves oral health but also systemic health, which in turn can improve the quality of life. In old age, the inability to maintain satisfactory to good oral health due to reduced functional ability and polypharmacy makes the oral environment favorable to dental diseases and tooth destruction. Therefore, it is necessary that policies must be tailored in a way that renders better access of dental treatment to frail and functionally dependent elderly patients (Lewis *et al.* 2015).

Despite of advances in oral health care, older people are still considered vulnerable to oral health problems globally. Tooth loss, dental caries, periodontitis, dry mouth, oral precancerous lesions, and oral cancer are considered as main conditions that need attention in older people. Research indicates that three main reasons make older people vulnerable to poor oral hygiene and make it difficult for them to maintain it (Lewis *et al.* 2015, Kossioni *et al*. 2018).

The first reason is personal related issues, which include physical illnesses, decreased mobility, cognitive impairment, poor socioeconomic background, living in rural areas or residential care and financial problems. Due to increasing age, people are suffering from chronic diseases which can hinder their ability to attend dental appointments. Moreover, with aging, people are becoming frail and dependent upon others for daily life activities, which can result in their reduced mobility. Besides, cognitive impairment is also one of the important issues in personal factors. People with dementia are seen to have care-resistant behaviors and cannot also reliably report oral health problems (Lewis *et al*. 2015, Kossioni *et al*. 2018). Second reason is lack of professional support, which means that non-dental health professionals are not trained in oral health guidance. Third reason is, lack of effective health policies including lack of regulations for dental care in community and institutional care, high

cost of treatment and limited coverage of dental care for public (Lewis *et al.* 2015, Kossioni *et al*. 2018).

2.1.2.1.2 Genetics

It has been hypothesized that genetics may play a role in oral diseases particularly periodontal disease. Familial Aggregation studies and Twin studies have been done to see the effect of genetics on periodontal diseases. Familial studies and Genome-wide studies suggest that an aggressive form of periodontitis has a stronger genetic association as compared to chronic periodontitis. However, Twin studies suggest that there is a possible role of genetics in chronic periodontitis; with half of all the variations in periodontal diseases are due to genetic factors (Genco & Borgnakke 2013). Some studies also suggest that genetic polymorphisms in cytokine genes can modify the systemic inflammatory response in people with periodontitis (Kornman *et al*. 1997, D'aiuto *et al.* 2004). Although several studies indicate an association of genetic polymorphisms with periodontitis, there is a lack of enough evidence to support the causation (Pihlstrom *et al.* 2005).

There are also some genetic diseases that can have severe periodontal manifestations some of them are Haim-Munk and Papillon-Lefèvre syndromes which are autosomal recessive disorders caused by mutation of cathepsin C gene, Chédiak-Higashi syndrome, Ehlers-Danlos syndrome types 4 and 8, Kindlers and Cohen syndromes (Pihlstrom *et al.* 2005).

2.1.2.2 Socioeconomic factors

Socioeconomic status affects oral health as well as oral health-related quality of life. A study by Peres *et al.* (2013) concluded that people with lower income and education level, experience a greater impact of oral health on quality of life. According to the research, adolescents who are from low-income families are more likely to experience difficulties in chewing and psychosocial problems in their daily lives compared to those from high-income families (Peres *et al.* 2013).

According to WHO, social determinants of health play an important role in the maintenance of oral health. Socioeconomic status, which is one of the social determinants of health contributes significantly to the burden of oral diseases globally. Variation in socioeconomic status results in differences in the prevalence of oral diseases according to geographical areas, being high in low and middle-income countries. These differences in prevalence are not only common between countries but, also within countries. In developed countries, the burden of

oral diseases is estimated to be higher in people with low socioeconomic status and among disadvantaged populations (WHO 2012).

Studies have been conducted to evaluate the role of sociodemographic factors in poor oral health. A study conducted by Esan *et al*. (2004) found a significant relationship between socio-demographic variables i.e. age, educational level, and socioeconomic status and edentulism. Poor education which is one of the risk factors for poverty has been identified as a major factor in edentulism. This may be because people with higher education tend to have good oral hygiene habits, enhanced dental health awareness and increased utilization of oral health facilities. The study further concluded that people with higher socioeconomic status tend to demand fewer dentures than people with low socioeconomic status because people with higher socioeconomic status retain their teeth for longer (Esan *et al.* 2004).

Measures of socioeconomic status i.e. income, education level and living in rural or urban areas are also considered as significant predictors for periodontal disease. People with low socioeconomic status are at higher risk of developing periodontal diseases than people with higher socioeconomic groups. This difference can be explained by the difference in environmental and behavioral factors in two groups (Albandar 2002). According to Almerich-Silla *et al.* (2017), low educational level and low social class have a statistically significant relationship with the prevalence of periodontal pockets (Almerich-Silla *et al.* 2017).

Similarly, Costa *et al.* (2012) found a positive association between socioeconomic status and the prevalence of caries. According to the study, there has been a decline in dental caries in industrialized countries during the past 20 years, because of public health interventions and health promotions. However, these promotional activities are more accessible to people with higher socioeconomic status. Moreover, it is also evident that people with high incomes have better access to oral health services, oral care products and oral health knowledge (Costa *et al.* 2012).

2.1.2.3 Behavioral and lifestyle factors

2.1.2.3.1 Oral hygiene practices

Among a range of risk factors for poor oral health, poor oral hygiene practices and inadequate exposure to fluorides, both have a negative effect on oral health (WHO 2018). Maintaining good oral hygiene is important to prevent most common preventable oral diseases like caries, periodontitis, tooth loss and halitosis (bad breath). Good oral hygiene can be maintained by

removing dental plaque and debris. Plaque, which is the most important etiologic factor for most common oral health diseases like periodontitis and caries, can be removed by regular tooth brushing twice a day with fluoride toothpaste, flossing and using mouthwash (Holt *et al.* 2001, Hayasaki *et al*. 2014).

The use of fluoride has also been considered as the foundation for the prevention and control of caries. Fluoride stops caries progression, reduce the rate of tooth demineralization, promote remineralization and sometimes under certain conditions, can halt carious lesion (Petersson 2013). According to a meta-analysis by Griffin *et al.* (2007), topical use of fluoride either self or professionally applied and use of fluoride in drinking water can prevent as well as reverse coronal and root caries among adults of all age groups (Griffin *et al.* 2007). In addition, in a randomized controlled trial, professionally applied fluorides such as 38% silver diamine fluoride (SDF) solution and 5% sodium fluoride varnish were also found to be effective in preventing new root caries (Tan *et al*. 2010). Moreover, root caries in at-risk groups can also be prevented by brushing teeth with fluoride toothpaste having 5,000 ppm fluoride and by use of fluoride mouthwashes with 0.025–0.1 % fluoride solutions (Petersson 2013). Therefore, tooth brushing behavior (motivation, duration, technique and force of brushing), flossing and use of appropriate fluoride toothpaste are key determinants and tools in maintaining oral prophylaxis (Hayasaki *et al.* 2014).

2.1.2.3.2 Smoking and alcohol consumption

Among the modifiable risk factors for oral cancers, smoking and alcohol consumption are considered as the most important and common risk factors in oral cancer development. The risk of developing oral cancer increases with both frequencies i.e. number of cigarettes per day or week, and duration i.e. years of smoking or drinking. In addition, the risk of oral cancer becomes higher with the combined use of tobacco and alcohol. Apart from smoking, use of smokeless tobacco in the form of snuff and betel quid with or without tobacco is also considered as a risk factor for oral squamous cell carcinoma particularly in Asian countries *(*Radoï *et al.* 2013*,* Winn *et al*. 2015).

Smoking not only causes oral cancer but also affects periodontal tissue. Numerous studies support the evidence that smoking is an important risk factor in the prevalence as well as the advancement in the disease process of periodontitis. The risk of periodontitis increases with the duration of smoking and the number of cigarettes consumed. Evidence also suggests that

smokers usually present with more severe periodontitis. Moreover, they exhibit higher probing depths of greater than 5mm, higher rates of furcation involvements, and tooth mobility due to extensive periodontal loss as compared to non-smokers. Smoking not only affects the periodontal disease process, but also slows down periodontal healing after treatment as compared to non-smokers, and the healing is often not complete (Obeid & Bercy 2000).

2.1.2.3.3 High consumption of sugars

It is a well-established phenomenon that sugar consumption plays an important role in the development of dental caries. Sugars act as a substrate for cariogenic bacteria especially mutans streptococci that resides in plaque. Cariogenic bacteria metabolize sugars and produce acid by-products. These acids by-products cause demineralization of the enamel surface. After demineralization, the lesion can either remineralize or proceed to clinically detectable caries, depending upon the frequency of further consumption of sugar. Therefore, sugars play an important role in the initiation of demineralization of enamel and further progression of caries (Brian *et al*. 2001).

The systematic review by Brian *et al.* (2001) concluded that people who consume sugars in large amounts or frequently are more prone to have cariogenic bacteria in their saliva than people who have low consumption. Sugar consumption is considered as mild to moderate risk factor for caries in the presence of good exposure to fluoride. Therefore, sugar restriction in diet plays an important role and is justified in the prevention of dental caries (Brian *et al.* 2001).

2.1.2.3.4 Stress

Clinical and epidemiological studies suggest that depression, anxiety, and stress can be a risk factor for periodontitis (Pihlstrom 2005, Stabholz *et al.* 2010). Psychological stress in an individual can cause clinical periodontal attachment loss and alveolar bone loss (Van Dyke *et al.* 2005). There can be different mechanisms through which stress can promote periodontal disease progression. The proposed biological mechanism through which stress can cause periodontal destruction is immunosuppression. Stress can induce the release of noradrenaline, corticotropin-releasing hormone, and glucocorticoid hormone; this can increase the release of proinflammatory cytokines including IL-6 that in turn can cause periodontal tissue destruction. (Van Dyke *et al*. 2005, Stabholz *et al*. 2010, Genco *et al.* 2013). Another

mechanism is health-impairing behaviors or behaviors that can have harmful effects on periodontal health, such as under psychological stress, a person can increase smoking, pays little attention to oral hygiene, visits the dentists less regularly and can start eating an unhealthy diet. All of these can affect the health of periodontium through an increase in plaque level or suppression of the immune system (Stabholz *et al*. 2010, Genco *et al.* 2013).

2.1.2.4 Systemic diseases

With an aging population, multiple chronic diseases are becoming prevalent, and these diseases are expected to increase among old people during the coming decades. Some common chronic diseases which share common risk factors with oral diseases are cardiovascular diseases, diabetes mellitus, malignant cancers, cerebrovascular diseases, and chronic obstructive pulmonary diseases. Some of these diseases are known to have a direct link with oral diseases, for instance, diabetes mellitus. Type 2 diabetes is known to have a two-way relationship with chronic periodontitis (Van Dyke *et al.* 2005, Stabholz *et al.* 2010). However, for other diseases, the indirect effect on oral health can occur in the form of side effects of treatment medicines on oral health (Ghezzi & Ship 2000).

In addition to systemic health, mental health is now becoming one of the biggest problems in elderly people due to the increase in the prevalence of dementia and Alzheimer's disease (AD). Due to loss of intellectual function and memory in dementia and AD, these people are at risk of having poor oral hygiene, periodontitis, and edentulism unless they are assisted in oral hygiene care by family or caregiver. In addition to dementia, people with Parkinson's disease (PD) are also at risk of poor oral health, chewing difficulties, dysphagia, and tooth loss. For PD patients' daily tooth brushing and denture cleaning becomes difficult due to resting tremors, bradykinesia and akinesia (Ghezzi & Ship 2000, Kandelman *et al.* 2008).

Apart from the above mentioned mental and systemic diseases, some other diseases also have oral complications such as Sjögren syndrome. People suffering from this syndrome experience the absence of saliva due to the destruction of salivary glands. Due to a lack of salivary protection, they are at risk of dental caries, mucosal infections, oral discomfort, and dysphagia. Patients undergoing chemotherapy or radiotherapy experience the same symptoms as Sjögren syndrome (Slavkin & Baum 2000).

Some rare diseases can also have an association with oral diseases particularly periodontitis. Some of these diseases are disorders in neutrophil function such as Chediak-Higashi

syndrome, cyclic neutropenia, agranulocytosis, and Down syndrome and Papillon Lefevre syndrome. However, all these diseases are very rare, hence further studies are required to explore the association of these diseases with periodontitis (Deas *et al.* 2003).

2.1.2.5 Polypharmacy

As mentioned earlier, due to an increase in the aging population chronic diseases are becoming more prevalent. Some of these diseases do not have any direct association with oral health but the treatment of these diseases can have deleterious effects on oral health. There are around 400 therapeutic drugs that are known to reduce salivary secretion and can have similar consequences like Sjögren syndrome (Slavkin & Baum 2000). Antihypertensive drugs such as beta-blockers, calcium channel blockers, and diuretics are known to produce oral effects such as salivary dysfunction, gingival enlargement, lichenoid mucosal reaction (from thiazides) and taste disturbance. Disturbance of taste has been seen with a wide variety of drugs such as hypoglycemics, antiarthritic, anesthetics, antidiarrheal, antiparkinsonian and sympathomimetics (Ghezzi & Ship 2000).

Other drugs such as immunosuppressants and corticosteroids, depress the immune system and cause oral candidiasis, recurrent oral viral infections, vesiculoulcerative stomatitis, taste disorders and gingival enlargement (due to use of cyclosporine). In addition, most frequently occurring cancers although they do not have a direct effect on oral health their treatment with surgery, radiation, and chemotherapy can seriously affect oral health resulting in mucositis, stomatitis, recurrent microbial infections, permanent salivary gland dysfunctions, taste disturbance and increased risk of osteoradionecrosis. Therefore, systemic diseases and their treatments can impair oral health and thus can increase the burden of diseases (Ghezzi & Ship 2000).

2.1.3 Dental caries and periodontitis - most prevalent oral health problems

2.1.3.1 Caries

2.1.3.1.1 Definition

Dental caries which is commonly known as tooth decay is defined as a “multi-factorial infectious and transmissible disease caused by bacteria residing and colonizing tooth surface”. (Caufield *et al.* 2005). It is a disease process that destroys tooth structure in the form of cavitation (Usha *et al.* 2009). It results due to the interaction of plaque microorganisms, diet

and a range of host factors. Host factors include social, environmental and genetic factors along with the immunologic response of the host (Yada *et al.* 2017).

2.1.3.1.2 Pathogenesis of caries

Dental Caries is a complex process that requires the presence of multiple factors particularly cariogenic microorganisms, dietary sugars, and plaque. The concept of the involvement of microorganisms in the process of caries is known since long. The process was first described by Miller in 1980 in his chemo-parasitic theory. The theory suggests that acidogenic bacteria present in the oral cavity plays an important role in carious process, they produce acids in the presence of fermentable carbohydrates which then demineralize the tooth enamel (Kleinberg 2002). Two groups of cariogenic bacteria are considered as important in the caries process; first is mutans streptococci and second is lactobacilli species. These bacteria in the presence of fermentable carbohydrates produce organic acids such as lactic acid, propionic acid, acetic acid, and formic acid all of which are capable of demineralizing enamel surface (Featherstone 2008).

The second most important component in the caries process is carbohydrates particularly sucrose. Oral microorganisms form a sticky matrix with some carbohydrates and stick to the teeth (Rajab & Hamdan 2002). Apart from sucrose, other carbohydrates such as cooked food containing high amounts of starch such as potato crisps and biscuits can also increase carious susceptibility due to its retentive properties (Kashket *et al.* 1991). Therefore, the frequency, as well as the time in which soluble carbohydrates remain in contact with the tooth surface, is highly significant in the development of caries (Dimitrova *et al.* 2002).

A third most important component in the caries process is dental plaque. Dental plaque is a biofilm that presents naturally on tooth structure. It is the substrate where oral microorganisms reside, and the change in this microflora to acidogenic bacteria can initiate the caries process (Marsh 2010). Plaque plays an important role in deciding whether demineralization of enamel will occur because of acid attack or not. In the presence of sugars, acidogenic bacteria of plaque produces acid that decreases the pH of plaque below critical pH (5- 5.5) after which there are chances that the enamel surface will be demineralized. At resting pH, plaque contains stores of calcium and phosphorus that prevent demineralization and initiates remineralization of enamel, following an acid attack. However, if the acid attack continues, a point is reached when calcium and phosphorus concentration of plaque is depleted, and net demineralization occurs. If the concentration of calcium and phosphorus are

present in plaque, demineralization cannot occur even in the presence of pH as low as 2.5 (Gao *et al.* 1991).

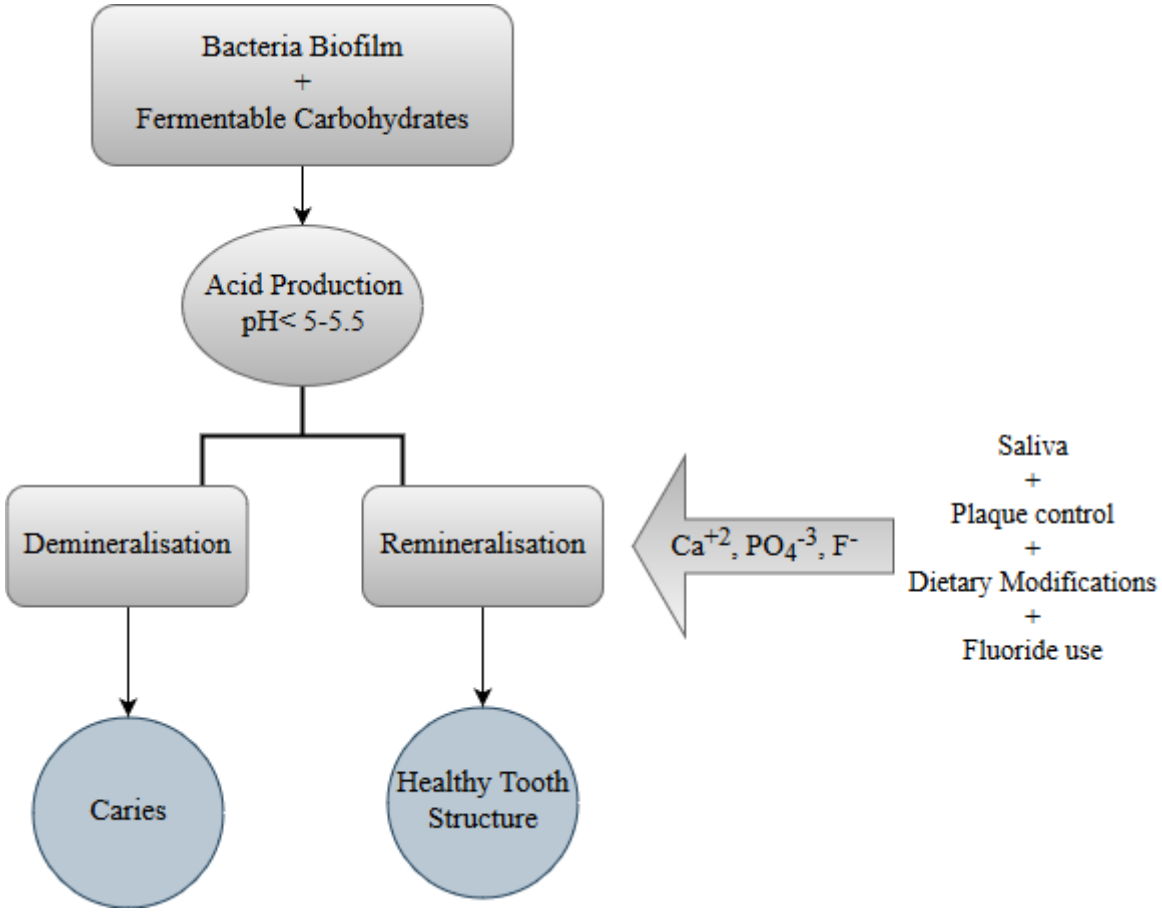

Figure 1: Pathogenesis of caries (Modified from Selwitz *et al.* 2007).

2.1.3.1.3 Epidemiology of caries

Caries is one of the most common oral diseases and a cause of tooth loss as mentioned earlier. According to WHO, caries is among the top five most expensive chronic diseases to treat. Globally around 60-90% of children and 100% of adults are affected by caries. It not only causes severe pain and discomfort to individuals but also causes biological, social and financial burden to the health care system (Peterson *et al*. 2005, Peterson 2008). According to a systematic review and metaregression conducted by Kassebaum *et al.* (2015), untreated caries is one of the most important public health challenges that countries are facing worldwide. According to the review, caries is now becoming more prevalent in adults than in children. In 2010, caries in permanent dentition was the most prevalent disease among all countries affecting 2.4 billion people worldwide whereas, it was the 10 most prevalent condition in deciduous teeth which affected 621 million children across the globe. The three

peak ages at which there is a higher risk of caries are 6, 25 and 70 years (Kassebaum *et al.* 2015).

The prevalence and incidence of caries vary among high and low-income countries. It has been estimated that open cavitated dentine lesions (present as cavities in the teeth in advance stage of caries) are more prevalent in low and middle-income countries as compared to high-income countries (Frencken *et al.* 2017). Generally, some studies indicate a decrease in the prevalence of caries in the last few decades in developed countries and an increase in developing countries particularly in Africa (WHO 2003, Petersen *et al*. 2005). However, a systematic review by Kassebaum *et al.*(2015) suggests that caries prevalence and incidence remained static between 1990-2010 among all the countries in the world. It further suggests that there is a risk that 15 and 27 new cases of caries in primary and permanent dentition respectively will appear annually on the follow-up of every 100 people (Kassebaum *et al*. 2015).

In Finland, according to the Health 2000 Survey, 31% of Finnish adults' age 30 and greater have caries. The prevalence of caries is more common in men than women and also more common among elderly people as compared to the age group 30-44 years. On average, men have 0.8 decayed teeth and women have 0.5. Besides, dental caries is less commonly seen in people with higher education and people who brush their teeth twice a day as compared to people with basic education and people who brush their teeth less than daily (Suominen-Taipale *et al.* 2008).

2.1.3.1.4 Risk factors for caries

The concept that three main factors i.e. microbial dental plaque, susceptibility of the tooth towards caries, and a diet that offers a regular supply of fermentable carbohydrates must be present simultaneously for the occurrence of dental caries is accepted since a century ago (Burgess 1988, Hunter 1988). Since that time multiple general and specific risk factors have been identified that increase one's susceptibility to caries, these include physical, biological, behavioral, environmental and lifestyle-related factors (Selwitz *et al.* 2007).

Numerous studies identified local as well as general factors that increase the risk of caries. Local factors include the structure of a tooth and its position, salivary flow of an individual and oral hygiene. Among general factors, age, sex, race, geographical location, social class,

and ethnicity are the most prominent factors which can increase the risk of caries among individuals (Hunter 1988, Selwitz *et al*. 2007, Namal *et al.* 2008).

In addition, several studies have acknowledged the importance of socio-behavioral risk factors in the development of caries (Tervonen *et al*. 1991, Namal *et al.* 2008). Previous studies have identified that certain socio-behavioral factors like ethnicity, low education status, low family income, urbanization, high frequency of sugar intake including sugary beverages, tooth brushing habits, dental attitudes and the number of dental visits increases the odds of dental caries (Tervonen *et al.* 1991, Peterson 2005).

The risk factors for caries are in common with the risk factors for other chronic diseases therefore, a common risk prevention approach must be followed to prevent dental caries and other oral diseases (WHO 2002, Peterson 2003).

2.1.3.2 Periodontitis

2.1.3.2.1 Definition

Periodontitis is defined as an “inflammatory disease of the tooth-supporting structure caused by a group of microorganisms residing in dental plaque; which results in the formation of the periodontal pocket, gingival recession or both due to the progressive destruction of periodontal ligament and alveolar bone” (Newman *et al*. 2006). It is a complex infectious process that results from an interaction between bacterial infection and host response, which is further modified by factors such as genetic susceptibility, acquired and environmental risk factors (Saini *et al.* 2009).

2.1.3.2.2 Pathogenesis of periodontitis

The classical model of the pathogenesis of periodontitis was first developed by Page and Kornman in 1997. Since then, research is ongoing to unleash the complex relationship between plaque biofilm and its microorganisms and host response. Previously it has been accepted since ages that periodontitis is triggered by the presence of certain microorganisms in the plaque biofilm which is usually well known as "red complex". This red complex microorganisms are a group of three species which includes Porphyromonas gingivalis, Treponema denticola, and Tannerella forsythia. However, advancement in research has now developed a new model of periodontitis, which proposes that the disease does not occur by periopathogens like red-complex, rather it initiates by synergistic and dysbiotic microbial

organisms (Hajishengallis & Lamont 2012). Till now 700 organisms are known as possible components in the disease process (Aas *et al*. 2005).

In a healthy tooth, a biofilm is present in which microorganisms and host responses have a symbiotic relationship. If this biofilm is not disrupted from time to time and allowed to accumulate than due to change in the local environment, it starts increasing the number of pathogenic bacteria to a level that can initiate periodontitis. This biofilm can also make the conditions favorable to bacterial species that can sense and influence the environment and can elicit strong host immune response (Marsh 2003, Meyle & Chapple 2015). Due to microbial challenge, host response results in the release of cytokines, eicosanoids and other inflammatory mediators such as matrix metalloproteinases (MMP), kinins and complement system that can further aggravate the response and cause connective tissue and bone destruction (Page & Kornman 1997).

Although, it has been accepted that bacteria are essential for the initiation of the disease process but, alone they are insufficient for the progression of the disease (Page & Kornman 1997). The disease occurs due to the complex interaction of microorganisms in plaque biofilm with the inflammatory immune response of the host. The immune response of the host accounts for an 80% risk of destruction of periodontal tissue (Hajishengallis 2010). Not only initiation, but the severity of resultant periodontitis is also dependent upon the host related parameters (Hajishengallis 2014). It can be stated that the whole disease process of periodontitis is influenced by disease modifiers which are both genetic and environmental or acquired (Page & Kornman 1997).

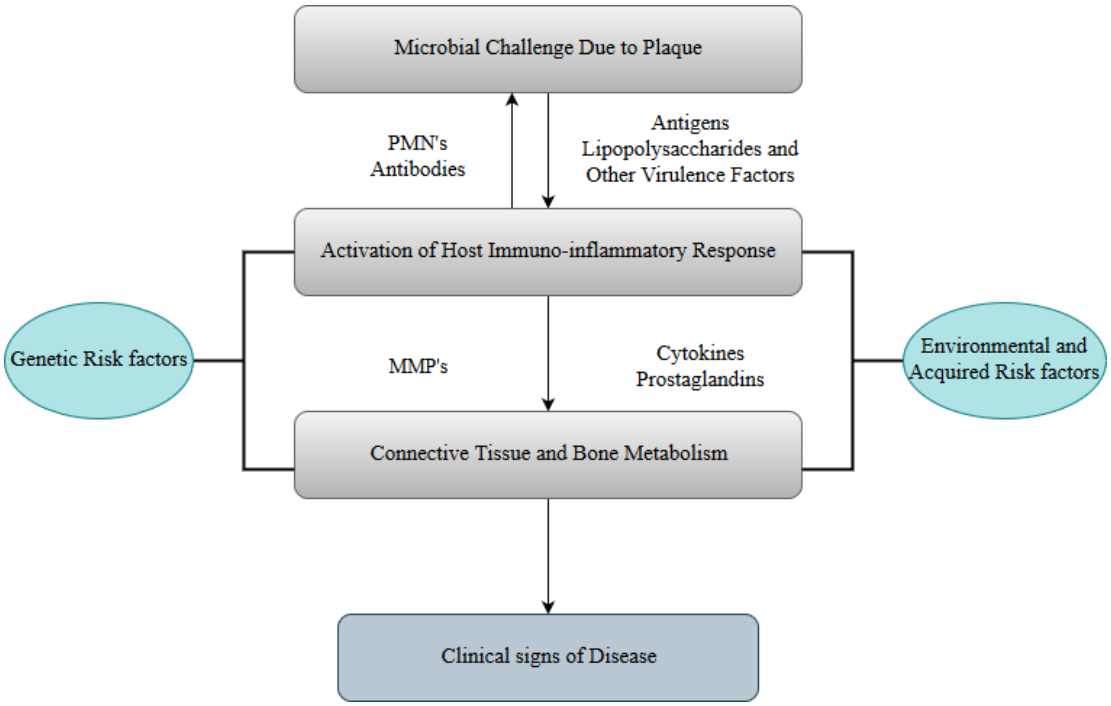

Figure 2: Pathogenesis of periodontitis (Modified from Page & Kornman 1997).

2.1.3.2.3 Epidemiology of periodontitis

Periodontitis is one of the major dental diseases that has affected humans all around the world at high prevalence (Peterson 2003). The prevalence of the periodontal disease varies between countries and within countries; being high in low socioeconomic countries. Moreover, racial and ethnic disparities in prevalence, as well as the severity of the disease, has also been seen within countries. These variations are due to socioeconomic conditions, environmental and behavioral factors, general health status such as the presence of systemic diseases and others. Due to its prevalence, the global burden of periodontal disease has increased from 1990 to 2010 by 57.3% (Kassebaum *et al.* 2014a, Tonetti *et al.* 2017).

Periodontitis does not only affect an individual but also cause an economic burden to the society, due to disability and loss of productivity. According to the Global Burden of Disease Data (GBD) 2015, periodontitis accounts for 3.5 million years lived with disability. The total direct and indirect cost due to periodontal diseases incurred in 2010 is 442 billion dollars and only from severe periodontitis, the global cost due to loss of productivity is estimated to be 54 billion USD per year (Tonetti *et al.* 2017).

Prevalence and severity of periodontitis are measured in different developed and developing countries using different designs and measurement criteria. The Community Periodontal

Index (CPI), which is the standard of measuring periodontal health was introduced by WHO. In addition to helping in standardized measurement, data from CPI is helpful in the surveillance of the disease at the country and inter-country level. According to WHO World Oral Health Data Bank, CPI score 2 which indicates gingival bleeding and calculus is the most prevalent among all age groups in all regions. However, severe signs of periodontitis which is indicated by score 4 vary worldwide from 10% to 15% in the adult population (Peterson & Ogawa 2005). Prevalence of severe periodontitis usually increases between the third and fourth decades of life and reaches its peak at the age of 40 years. However, it remains stable in old age (Kassebaum *et al.* 2014a).

In Finland, according to the Health 2000 Survey, 64% of all dentate adults have periodontitis with at least one tooth having periodontal pocket ≥4mm. Besides, 21% of dentate subjects have a severe form of periodontitis which is characterized by, at least one tooth with periodontal pocket ≥6mm. On average, the number of teeth affected by periodontitis is 4.2 (≥4mm) and 0.7 (≥6mm). Moreover, periodontitis is more common among people with age 45-54 in men and 55-64 in women. However, the severe form of periodontitis is most common in people aged 65+ in men and 55-64 in women. Gender differences have also been noted in the prevalence of periodontitis, being more common in Finnish men than women (Suominen-Taipale *et al.* 2008).

2.1.3.2.4 Risk factors for periodontitis

Both oral health and systemic health are inter connected to each other. Owing to this fact, both periodontitis and four most common non-communicable chronic diseases (cardiovascular diseases, diabetes, cancers and chronic obstructive pulmonary disease) have common and preventable risk factors related to lifestyle such as tobacco and alcohol consumption, stress, poor diet, poor oral hygiene and others (Peterson 2003, Peterson & Ogawa 2005). Several systematic reviews have been published to identify the list of risk factors for periodontitis, according to these studies risk factors for periodontitis can be classified as modifiable and non-modifiable risk factors.

Among modifiable risk factors; periodontal microorganisms, behavioral and lifestyle factors such as smoking and alcohol consumption, diet, stress and oral hygiene practices, and diseases; such as cardiovascular disease, diabetes mellitus and obesity are reported by several studies to be the strong risk factors for periodontitis (Van *et al.* 2005, Genco & Borgnakke 2013, Al Jehani 2014).

Among non-modifiable risk factors, osteoporosis in post-menopausal women is strongly associated with periodontitis as it causes severe alveolar crestal bone loss. In addition, hematological disorders such as acute and chronic leukemia, host response, female hormonal alteration, and pregnancy are the ones that are strongly associated with periodontitis (Van *et al.* 2005, Al Jehani 2014).

Furthermore, there are some individual characteristics or risk characteristics that make a person more susceptible to periodontitis, such as age, gender, genetics, race, socioeconomic status and education (Al Jehani 2014). As the person ages, the severity of periodontitis and bone loss increases due to the increase in the length of time in which periodontal tissue remains in contact with dental plaque (Loe *et al.* 1986). In addition to age, the male gender is found to be more at risk of periodontal disease than females. The reason is not clear, but it may be due to ignorance of dental hygiene practices which are common among males more than females (Slade *et al.* 1995, Albandar & Kingman 1999). Socioeconomic status and level of education are also strongly related to periodontitis. People with low socioeconomic status and education are more prone to periodontitis and this difference in severity and prevalence seems to be present both within a country and between developed and developing countries (Peterson & Ogawa 2005).

2.2 Functional capacity

2.2.1 Definition

Functional capacity is the ability of an individual to perform daily routine tasks that are necessary and normally expected from certain age people. Functional capacity associates to the physical and mental state of an individual and is an important indicator for the assessment of the quality of life. With an increase in life expectancy, the proportion of people with extreme old age is increasing dramatically, which has now made it very important to evaluate the functional capacity of individuals (World Health Organization 2011). Therefore, functional capacity evaluation is emphasized in order to evaluate people who need long-term care and support that includes a large proportion of old age people (Encyclopedia of Public Health 2002).

2.2.2 WHO International Classification of Functioning, Disability, and Health (ICF) Model

According to WHO International Classification of Functioning, Disability, and Health (ICF) model, functional disability or poor functional capacity can be the result of multiple factors i.e. either health conditions (diseases, disorders, and injuries) or contextual factors. Contextual factors are further categorized into external factors and internal factors. External factors include environmental factors such as social attitudes, climate, architectural characteristics, and others. Internal factors are personal factors which include age, gender, social background, education, profession, overall behavior pattern and other factors (WHO 2002).

According to this model, functioning occurs at three levels i.e. at the level of body or body part, at the whole-body level and the level of person in its social context. Functional disability can occur at any of this level i.e. if it occurs at body or organ level it causes impairments, if it occurs at whole body level it can cause functional limitations and if it occurs at the level of person in its social context it can cause participation restrictions (WHO 2002).

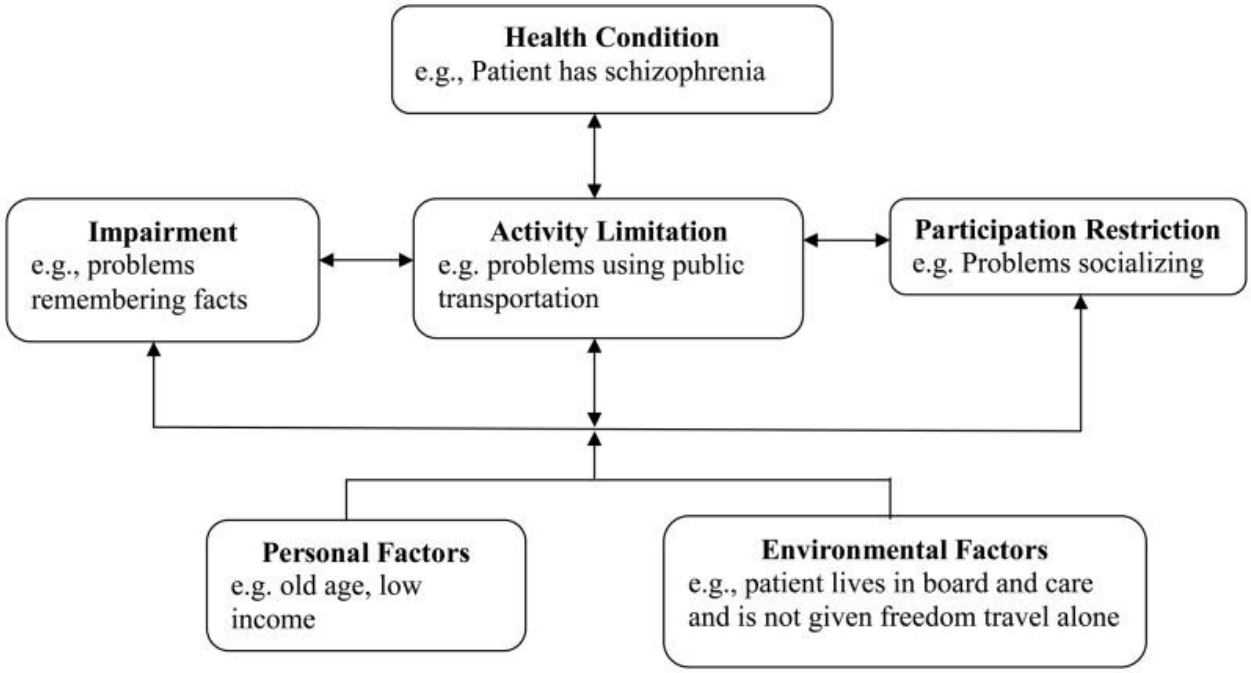

Figure 3: Model of functioning and disability (WHO 2002).

2.2.3 Global functional capacity

The population around the world is rapidly aging. This can have an enormous impact on social, economic and health care systems. Besides, global life expectancies are expected to

increase in the coming years. It is estimated that by 2045–2050 global life expectancy will be 83 years in developed countries and 75 years in less developed countries (United Nations 2013).

Due to an increase in life expectancies, the proportion of population aged 65 and above is increasing rapidly especially in OECD countries. According to OECD report on trends of severe disability which can be defined as one or more limitations in activities of daily living, there is a clear decline in disability among elderly people in last five to ten years among 5 of 12 OECD countries (Denmark, Finland, Italy, the Netherlands and the United States). However, the increasing trend of severe disability among people aged 65 and above have also been noticed in three countries (Belgium, Japan, and Sweden) while, disability rates were found to be stable in two countries (Australia, Canada). In France and the United Kingdom, different studies suggest different disability rates, which makes it impossible to draw an absolute conclusion (Lafortune & Balestat 2007).

Limitations in ADL and IADL have a direct relationship with increasing age. According to Chatterji *et al.* (2015), limitation in ADL becomes significant between age 50–70 in countries like Greece, Spain, and Italy. However, these limitations have a slow onset in countries like the Netherlands, Sweden, and Switzerland, where these limitations appear most commonly after the age of 70. With regards to IADL, the results are more consistent across countries i.e. IADL limitations are most commonly seen after the age of 70 among all those countries. Moreover, the decline in ADL and IADL is more common in females than males (Chatterji *et al.* 2015).

Functional disability in ADL and IADL among low- and middle-income countries have also been studied. However, the data for disability in those countries are limited and marked variation has been noticed among them. Even so, available data on functional ability in China and Thailand shows a decline in disability in ADL. On the other hand, disability in ADL has increased in Brazil between mid of the 1990s till 2012. The same trends have also been noticed for countries like Indonesia and the Philippines. In Thailand reverse in improvement in ADL has also been noticed after 2005 (Gu *et al.* 2014).

2.2.4 Functional capacity among the Finnish population

Surveys have been conducted from time to time in Finland to determine the health and functional capacity status in the Finnish population. The Mini Finland Health Survey was

conducted in 1977-1980 which was the first comprehensive combination of a health interview and health examination survey (Aromaa *et al.* 1989). The purpose of this survey was to study the population health, functional capacity and their need for treatment. Another survey was conducted in 2000-2001 which is the Health 2000 Survey. The main aim of the Health 2000 Survey was to acquire current information on public health problems in Finland and to determine their causes and treatment. The other aim was to obtain information on the functional capacity and working capacity of the Finnish population. Data from both surveys were compared in order to see the change of health and functional capacity in Finland (Aromaa & Koskinen 2004).

According to the Health 2000 Survey, most people aged 30 or over in Finland have quite good functional capacity and they can manage Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) without any difficulty. However, after age 65 or 75 performance in sensory, cognitive and other functions deteriorate and therefore, these age people usually begin to feel difficulty with some usual activities including recalling and memorizing. People who are age 85 or over not only have reduced sensory and cognitive functions but they also feel difficulty in basic activities of daily living (Aromaa & Koskinen 2004).

The comparison of the result of functional capacity of two surveys has shown that there is an improvement in the functional capacity of middle-aged and the elderly Finnish population. It has been seen that today, a larger percentage of the elderly can manage several everyday activities, which are necessary to maintain independent living without any difficulty. They can manage ADL and IADL such as walking a relatively long distance, shopping, climbing stairs and even heavy cleaning relatively better than before. The overall proportion of those people who have great difficulty with basic activities or who cannot manage these tasks at all appears to have decreased up to the age of 85 (Aromaa & Koskinen 2004).

The positive trends in development are due to two reasons, first; the living conditions in Finland have improved from past years and secondly; there have been improvements in disease prevention, early detection, and medical care. In addition, changes in people's lifestyle had a promotive effect on health and functional capacity of population (Aromaa & Koskinen 2004).

2.2.5 Domains

Functional capacity consists of three domains i.e. physical, psychological or cognitive and social domains.

Physical functional capacity can be defined as “a person’s ability to perform normal physical activities that are required in daily living”. Poor physical functioning or disability occurs when a person experiences problems or restrictions in performing normal activities of daily living. Poor physical functional capacity can occur as a biological process of aging or it can occur due to underlying health conditions. As people age, they suffer from chronic and degenerative diseases that affect their functional capacity and in turn increase the number of people suffering from functional impairment and disabilities (Hu *et al.* 2012).

There are some common health conditions or diseases that can affect physical functioning and cause disability. These include cardiopulmonary diseases, neurologic conditions, diabetes mellitus, cancer, obesity, dementia, affective disorders, ophthalmologic and auditory disorders, and fractures (Cathleen *et al.* 2013).

Cognitive functional capacity is” the ability of a person to perform cognitive functions that are necessary to acquire knowledge and perform daily routine tasks”. These functions include, attention, memory, orientation, executive functions (working memory, planning, reasoning decision making, and others) and language (reading, writing, comprehension, fluency, and others) (Mosby's Medical Dictionary 2009, Neuronup 2018). Cognitive decline can occur in certain diseases like dementia; which is defined as deterioration in memory, thinking, behavior and limitation in ADL. It is one of the major causes of disability and causes dependency in the older population. According to WHO, during recent years there are around 10 million new cases of dementia that are arising every year (WHO 2017). In Finland, dementia has become one of the major causes of death. The number of deaths due to dementia has become more than double in the last ten years. In 2016, nearly 9200 Finns died due to dementia and Alzheimer's disease (Statistics Finland 2017). Dementia compromises a person’s ability to live independently and is also one of the major causes of physical decline and loss of ADL and IADL (Project on Government Oversight POGO 2017). In addition, loss of ADL is also predictive of future cognitive decline and onset of dementia (Fauth *et al.* 2013).

Social functioning generally includes relationships and participation with other persons in an acceptable manner. The social functional capacity of a person is strongly dependent upon the

environment where the person lives. Social functioning of a person can be divided into the following dimensions: 1) social networks, 2) social activity and involvement, 3) loneliness, 4) social support, and 5) social skills (Tiikkainen & Heikkinen 2011).

A deficit in functional capacity can occur in any of these domains. If a person has physical impairment due to any reason, cognitive impairment, and problem in social skills or combination of these factors, it might interfere with the ability to perform routine activities and thus, create a deficit in functional capacity (Patterson *et al.* 2010).

2.2.6 Evaluation of physical, psychological and social functional capacity

As people get older they become frailer which makes them dependent in at least one activity of daily living, decreases their cognitive ability and restrict their outside mobility. This can be seen more commonly among people above age 75. Therefore, assessment of the functional status of an individual in old age is important to determine future healthcare and psychosocial needs and to address the immediate and long-term needs of an individual (POGO 2017). It can also help in predicting future health care costs and therefore, will increase the efficiency of resource allocation.

There are various grading scales and physical examination tests that can be used to determine the functional status and are often used in assessing the functional capacity of the elderly. Some of them are described below:

2.2.6.1 Evaluation of physical functioning

2.2.6.1.1 Activities of daily living (ADL) and instrumental activities of daily living (IADL)

To evaluate impairment in physical functioning most commonly used method is to assess Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL). These are the activities which can be performed independently but as people become aged their ability to perform these task decreases progressively, and assistance of a caregiver is then necessary (POGO 2017).

Activities of daily living are also known as the basic activities of daily living or physical activities of daily living. ADL involves activities such as grooming, feeding and toileting, dressing, transferring and continence. These skills are developed early in life and are preserved until mild or moderate cognitive impairment. Studies indicate that impairment in ADL can predict future cognitive impairment and onset of dementia regardless of current

cognitive status or depression. Functional impairment can even accelerate the process of cognitive decline. Among all categories of ADL, impairment in bathing poses the highest risk for future institutionalization (Jefferson *et al.* 2018).

To evaluate ADL, the Katz Index of Independence in ADL is the most commonly used scale to assess ADL. In clinical evaluation, the practitioner scores an individual as fully independent (no supervision, direction, or personal assistance needed) or dependent (needing supervision, direction, personal assistance, or total care) on each of the categories of ADL i.e. total six points. Therefore, a maximum score of six indicates that the person is fully independent, four points indicate that the person is moderately impaired, and two points indicate the severely impaired person (Michelle *et al.* 2016). During survey-based research, these activities are scored based on self-report (Iain Lang 2011).

IADL includes complex voluntary behaviors focused on a specific task. They include more complex activities than ADLs and are needed for living independently in a community (Mlinac & Feng 2016). Performing these tasks require neuropsychological organization and these tasks are therefore affected by mild cognitive decline. These activities include cleaning, shopping, managing finances, problem-solving, handling medication, and housekeeping (Avlund *et al.* 1996, Sikkes *et al.* 2009 Sanchez *et al.* 2011).

The most commonly used method to assess IADL is the Lawton-Brody scale. The scale was developed by Lawton and Brody in 1969 to evaluate the more complex ADLs that are necessary for living independently in a community. The scale can be used in a written questionnaire or an interview. In clinical evaluation, the practitioner scores an individual on all the categories in the scale as 0 which means dependent, or 1 which means fully independent and sum the eight responses. The higher score indicates a better ability to perform IADL and lower scores indicate dependence (Graf 2008). In survey-based research, IADLs are also scored based on self-report rather than rated by a clinician (Iain Lang 2011).

Other scales that can be used to assess ADL and IADL are Physical Self Maintenance Scale (PSMS) which can be used to assess ADL and can help to decrease possible age bias, the Older Americans Resources and Services (OARS) scale, which is a self-reported questionnaire including 14 questions measuring ADL and IADL. The questions are coded from 0 (completely unable) to 2 (without help) to check the level of functioning. Barthel ADL Index, which is a scale of 8 tasks for measuring ADL. In this scale, each task is scored from 0 to 100 points based on the performance in real-world setting over a period of 24-48 hours,

based on self-report or direct observation, and Functional Independence Measure (FIM) that can not only measure basic ADL but also social cognition and communication skills (Mlinac & Feng 2016).

In addition to self-reported scales, performance-based tests such as Performance ADL Test (PAT) and Erlangen Test of Activities of Daily Living (E-ADL-Test) can provide a thorough and more realistic evaluation based on person's true abilities. These tests are both quantifiable and repeatable (Mlinac & Feng 2016).

2.2.6.1.2 Evaluation of balance and gait

As a person gets older, balance and gait disorders increase significantly from 10% between ages 60 to 69 to around 60% in people of age 80 or older, which ultimately increases the chances of falls (Sudarsky 2001, Mahlknecht *et al.* 2013). Complications which result due to falls are one of the leading causes of death among older people. They are also associated with decreased functional status and increased use of medical services. It also affects the person's ability to perform activities of daily living, because to perform them; a person must have proper balance so that the tasks are done safely in the environment. The most commonly used test to assess gait disorder is Get Up and Go test and Timed Up and Go test (POGO 2017). Other tests that are also used to assess functional mobility are the Sit-To-Stand test with one and five repetitions, the Pick-Up-Weight test, the Half-Turn test, the Alternate-Step Test (AST), the Six-Meter-Walk Test (SMWT) and Stair Ascent and Descent tasks (Tiedemann *et al.* 2008).

2.2.6.1.3 Evaluation of hand grip strength

Hand Grip strength testing is an assessment technique commonly used to evaluate muscle strength. It is the simplest method of measuring muscle strength and function in clinical practice (Roberts *et al.* 2011). The most commonly used method to assess handgrip strength is a hand dynamometer. The most common indications of hand grip strength testing are to assess upper limb impairment, working capacity in people with hand injuries, people with other impairments and disabilities like rheumatoid arthritis and is also used to measure and predict future disability among older people (Innes 1999, Bohannon 2008).

The handgrip strength of a person starts to decline after midlife and continues decreasing progressively as a person age (Roberts *et al.* 2011). Therefore, it is also considered as one of the most important signs of frailty (Bohannon 2008). Studies indicate that handgrip strength

testing is an important tool to screen elderly people who are at risk of future disability both in ADL and IADL (Giampaoli *et al.* 1999). Low values of handgrip strength test are also associated with disability, poor health-related quality of life, falls, prolonged hospital stay and increased risk of mortality (Roberts *et al.* 2011).

2.2.6.2 Evaluation of psychological or cognitive function

To screen cognitive function psychometric assessment is usually performed. There are a wide variety of non-automated tests that can be performed to assess dementia. The most commonly used test is Mini Mental State Examination (MMSE) which can assess the severity of cognitive impairment as well as changes in cognition over time (Tombaugh *et al.* 1992). MMSE is a 30-point assessment tool that either uses the spelling of the word (backward) task or calculation task (Folstein *et al.* 1975). Out of 30; the score of 23 or less with education up to high school, and a score of 25 or less for people with higher education indicate significant impairment (Grace & Amick 2005).

Other non-automated tests that can be used to assess cognitive decline are the Abbreviated Mental Test (AMT); a short version of Long Mental Test Score. It includes only 10 questions from the Long Mental Test Score with the cut of value of <8 which is diagnostic of cognitive deficit, Six-Item Screener, Six-Item Cognitive Impairment Test (6CIT), Clock Drawing Test (CDT), Mini Cog, The General Practitioner Assessment of Cognition (GPCOG) (Woodford & George 2007), Syndrome Kurtz Test (SKT), Kew Test and The Kendrick Test (Wesnes & Harrison 2003).

Recently, several computerized tests are also available for the assessment of cognitive impairment; of them the three most commonly used tests are Cambridge Neuropsychological Test Automated Battery (CANTAB), Cognitive Drug Research (CDR), Computerized Assessment System and the Computerized Neuropsychological Test Battery (CNTB) (Wesnes & Harrison 2003).

2.2.6.3 Evaluation of social functional capacity

To evaluate social functioning, thorough information regarding each dimension of social functioning must be obtained. Interviews and questionnaires are the most commonly used methods to assess social functional capacity. They can include questions regarding social networks for instance number of children, the size of the household, marital status and others. Social activity can be evaluated through information regarding participation in leisure time

activities, health problems hindering leisure time activities and others. Social support can be evaluated through information regarding satisfaction with personal relationships, possibilities to get help and support from people close to oneself and others and finally, social skills can be evaluated through the ability to take care of matters together with other people (Lundqvist & Mäki-Opas 2016).

2.2.7 Determinants of functional capacity

2.2.7.1 Aging

Aging is a process that leads to several changes in humans' bodies with time. These changes include cellular alterations, sarcopenia, and cardiovascular dysfunction, which further reduces aerobic capacity. These changes are then followed by reduced physical fitness, which includes (strength, agility, and flexibility), loss of adaptability, decrease in functional capacity and eventually death. Because of these alterations in the body a geriatric syndrome called frailty occurs which eventually limits functional ability, quality of life and life expectancy in old people (Kowald & Kirkwood 1996, Afilalo *et al.* 2009, Riebe *et al.* 2009, Tuna *et al.* 2009).

Functional capacity of an individual decreases with aging because of the decline in aerobic capacity and muscle strength. This reduction in functional capacity makes a person dependent on family or friends for the completion of daily routine tasks, which includes standing up and sitting down, crossing the road and others (Abrass 1990, Langlois 1997). Therefore, to live independently in old age a certain state of functional capacity and health is required, and studies have identified that poor functional capacity is a risk factor that can also threaten independent living (Ahlqvist *et al.* 2016).

2.2.7.2 Multimorbidity

"Multimorbidity is defined as the co-occurrence of two or more chronic medical conditions" (Fortin *et al.* 2005). Population aging is a driving force behind the prevalence of multiple medical conditions such as dementia, stroke, chronic obstructive pulmonary disease, and diabetes. An increase in life expectancy means that there will be increased survival of people along with these conditions which will increase disability in older age (Suzmen *et al.* 2015). Multimorbidity is also associated with an increase in health care use, health care cost, emergency hospital admissions and a decrease in quality of life (Fortin *et al.* 2006, Bussche *et al.* 2011).

Multimorbidity is linked with a decline in functional capacity. A systematic review conducted by Ryan *et al.* (2015) found a positive association between multimorbidity and functional decline. The study concluded that the presence of multiple diseases can predict a future decline in functional capacity. The decline in function is more profound in individuals having a higher number of chronic medical conditions and greater disease severity, which can in the future worsen health outcomes (Ryan *et al.* 2015).

Thirteen chronic diseases have been reported in numerous studies to be associated with the development of physical functional disability. Some of these conditions are prevalent in the old population but some are less prevalent like stroke. Diseases like knee osteoarthritis, hip fracture, diabetes, stroke, heart disease such as (myocardial infarction, angina, and congestive heart failure), claudication, chronic obstructive pulmonary disease, visual impairment, depression, and cognitive impairment are most consistently reported in the studies as a risk factor for poor physical functioning (Satariano *et al.* 1990).

2.2.7.3 Socioeconomic conditions

Several studies have pointed out the difference in socioeconomic status and its effect on functional capacity. A study conducted by Ono *et al.* (2015) among older adults in Brazil concluded that the chance of mild or moderate to severe disability decreases if a person has a high level of education and has paid work (Ono *et al.* 2015). Sulander *et al.* (2006) examined a 10-year trend in functional capacity by gender, age, and education among elderly Finns and concluded that a higher level of education is correlated with better functional capacity especially in ADL (Sulander *et al.* 2006). Another longitudinal follow up study conducted by Sulander *et al.* (2012) also concluded that socioeconomic status has an impact on functional ability, with poor adequacy of income is consistently associated with poor functional capacity (Sulander *et al.* 2012). According to English Longitudinal Study of Aging (ELSA), wealthier people show a lower incidence of disability and are also expected to remain disabled for less time as compared to people with low socioeconomic status (D'Orsi *et al.* 2014).

2.2.7.4 Behavioral and lifestyle factors

Behavior and lifestyle play an important role in maintaining functional status and quality of life in old age. Behavioral factors like routine physical activity play a significant role in the maintenance of functional independence and preventing disability in old age (Paterson *et al.* 2010). A study from the English Longitudinal Study of Aging (ELSA) found a significant

association between lifestyle factors and a decline in IADL. The study concluded that lifestyle factors such as physical activity, smoking status, high quality of life, cultural activities and digital literacy play an important in the maintenance of IADL. A good quality lifestyle can recover any decline in IADL and can even diminish the effects of wealth on IADL. Digital activity such as the use of the internet was found to be protective against a decline in IADL. Because in older adults, increased or maintained intellectual activity is important to maintain IADL. Therefore, digital literacy can maintain intellectual activity in older age. The study further suggests that vigorous physical activity also prevents a decline in IADL and even speed up the recovery process (D'Orsi *et al.* 2014).

A study by Ahlqvist *et al.* (2016) on the factors associated with independent living in old age propose that not only age and health conditions but behavioral and lifestyle factors such as smoking, participation in activities outside the home and physical activity play an important role in independent living in old age. Smoking, low physical activity, and loneliness can worsen the functional capacity status in old age (Ahlqvist *et al.* 2016).

According to Sulander (2011), certain health-related behaviors like current smoking, healthy diet which is characterized by consumption of fruits and vegetables and physical activity are associated with functional capacity; people having current smoking status, no daily use of fruits and vegetables and physically inactive lifestyle have poorer functional capacity as compared to those who are non-smokers, use fruits and vegetables daily and have active lifestyles (Sulander 2011).

2.2.8 Importance of evaluating physical functional capacity

The importance of functional capacity evaluation was first recognized in 1950 when due to an increase in age, the number of disabled people increased, and chronic diseases became more prevalent (Katz & Stround 1989). With the continuing aging of society, limitation in physical functioning is currently becoming one of the most prevalent public health issues and a matter of urgency. Age-related functional limitations start to appear as early as midlife and increase across time. Therefore, it is essential to measure physical functioning particularly in middle-aged and older adults (WHO 1998, Tomey *et al.* 2009).

Physical function evaluation is a good indicator for current health status and can predict the future functional status of an individual since people with poor physical functional capacity are at risk of falls and fractures, which can lead to disability in subsequent years. People with

physical limitations are also more likely at risk of depression that can further decrease their quality of life (Tomey *et al.* 2009, Iain Lang 2011).

Also, physical functioning is important to maintain the social functioning of an individual. It helps a person to maintain independent living, participate in events, meet other people, use health care services and other facilities provided, and in general improve their lifestyle and people associated to them (WHO 1998).

Due to the increased prevalence of physical functional limitations, social and financial costs are increasing. Therefore, it is vital to evaluate physical functional capacity as it can predict future use of health care services, for instance, hospital admissions and social services including nursing home admissions (Tomey *et al.* 2009, Iain Lang 2011).

2.3 Association of physical functional capacity with caries and periodontitis

Physical functional capacity not only affects general health but also affects oral health and wellbeing. There are several cross-sectional studies (Jette *et al.* 1993, Morishita *et al.* 2001, Avlund *et al.*2004, Vilstrup *et al.* 2007, Yu *et al.* 2011, Komulainen *et al.* 2012) identifying the fact that poor physical functional capacity in old age affects the oral health of the aged population substantially. A study conducted in Nova Scotia, Canada on population above 45 years of age suggested that oral health problems are highly prevalent among the older population. Oral health problems and self-care impairment are also seen as the most important and prevalent problems in nursing home residents because of their poor functional capacity (Matthews *et al.* 2012). The study conducted by Avlund *et al.* (2001) proposed that old persons with poor physical functional capacity are more likely to have no or reduced number of teeth, experience more chewing difficulties, and are less expected to visit the dentist regularly than others (Avlund *et al.* 2001). Similarly, according to Yu *et al.* (2011), physical functional disability can be correlated with poor oral health, which is defined as edentulism, moderate to severe periodontal disease, or need for periodontal treatment (Yu *et al.* 2011). Older adults with functional limitations are considered at higher risk of root caries (Avlund *et al.* 2004). A reason of this may be the presence of gingival recession in old age; with only a small amount of gingival recession the root becomes susceptible to caries (Rockville 1991, Gillbert *et al.* 2001, Saunders & Meyerowitz 2005).

Study on home-dwelling elderly patients dependent on moderate or substantial supportive care for their daily living also indicates that the prevalence of dental caries and bleeding gums

are more common among individuals with substantial need of supportive care (Holmen *et al.* 2012). A study by Morishita *et al.* (2001) on homebound elderly people indicates that subjects with higher activity of daily living demonstrate better oral hygiene and better diets than those persons which have low ADL (Morishita *et al.* 2001).

Studies have also been conducted to determine the association of functional capacity and oral health in frail elderly people and people with cognitive disabilities residing in nursing homes. According to Saarela *et al.* (2013), frail older residents who need more assistance in performing activities of daily living and elders who suffer from cognitive impairment often brush their teeth and clean their dentures less than once daily which can further augment other oral health problems and malnutrition (Saarela *et al.* 2013). According to the study on residents of the nursing home in Sweden; old residents who are dentate but have lost their functional capacity (ADL) or cognitive ability are more in need of dental treatment due to poor oral hygiene (Nordenram *et al.* 2002).

As this study mainly focuses on the physical domain of functional capacity, therefore, now onwards the term functional capacity will refer to physical functional capacity.

2.4 Justification of the study

This study was conducted to assess the association of functional capacity with the increased risk of dental caries and periodontitis in a sample of Finnish adult population within a longitudinal setting. Table 1 summarize previous studies that associate functional ability with oral health, seven studies were cross-sectional and three were conducted in longitudinal settings. In most of these studies, the main limitation was their cross-sectional design from which cause and effect relationship cannot be determined. In previous longitudinal studies, functional ability and oral health were measured using different methods. Also, most of these studies were conducted on frail elderly nursing home residents and people with cognitive disabilities particularly dementia and Alzheimer's disease. Therefore, their results cannot be generalized to populations.

This study not only included participants from old age group but also other age groups i.e. adults, middle-aged and elderly people. To the best of our knowledge, there is no previous study exploring the longitudinal relationship between functional ability and risk of caries and periodontitis in a sample of the Finnish adult population. This study will elucidate the effect of functional ability on oral health in middle-aged and elderly people.

Table 1. Cross-sectional and longitudinal studies associating functional ability with oral health.

AUTHOR	DESCRIPTION OF PARTICIPANTS	EXPOSURE ASSESSMENT	OUTCOME ASSESMENT	CONFOUNDERS	RESULT
Holmen *et al*. (2012)	N=302 Age= ≥ 65years Design= Cross-sectional	Substantial needs of supportive care: Three times per day with night monitoring. Moderate needs of supportive care: 15–50 h every month.	Number of teeth, DT*, DFT*, periodontal pockets>5mm, bleeding on probing, tooth mobility, use of dentures, dry mouth and chewing capacity through Eichner's index	Age, gender, heart disease, diabetes, frequent pneumonia, number of medications	Individuals with substantial needs of supportive care had more caries and bleeding gums than individuals who needed moderate supportive care.
Philip *et al.* (2012)	N= 205 Mean age= 85± 9.8 years Design= Longitudinal	Self -care ability measured by activities of daily living oral health (ADLOH) in participants with dementia and without dementia	Caries experience, active caries, retained roots and root caries measured by DMFT* index.		Caries experience, active caries and carious retained roots were higher in patients with disability related with dementia; functional ability was associated with experience of caries.
Komulainen *et al.* (2012)	N= 168 Females= 116 Males= 52 Mean age=80.6 Design= Cross-sectional	IADL*and hand grip strength	Tooth brushing frequency, tooth paste use and oral hygiene measured by presence of dental plaque	Age, gender, education, number of teeth, feeling of dry mouth, having own dentist, MMSE* score for cognitive status.	Functional ability measured by IADL scale was significantly associated with oral self-care among home dwelling elderly.
Sanchez-Garcı´a *et al.* (2011)	N=698 Age= ≥ 60years Design= Case-cohort: Longitudinal	Sociodemographic variables, general health, healthy oral and general behavior, salivary condition, cryogenic microorganisms	Development of root caries in a 12- month period		Limitations in basic activities of daily life, smoking, not using mouthwash, elevated counts of

		and clinical indicators of oral health, functional capacity (ADL and IADL) *. Cognitive ability (MMSE score), Depression (GDS*).		-	mutans streptococci, high exposure of root surfaces and previous experience of root caries increased the risk of new root caries within 12 months
Yu *et al.* (2011)	N=3,856 Age= ≥60 Mean age= 71.2 Design= Cross-sectional	Functional dependence in ADL and IADL, leisure and social activities (LSA), lower extremity mobility (LEM), General physical activities (GPA)	Edentulism, severity of periodontal disease and recommendation of periodontal care.	Demographic and dental variables, C-reactive protein, health related behaviors and comorbidities	Edentulism and severe periodontitis was associated with multiple domains of late life disability.
Vilstrup *et al.* (2007)	N=191 Men= 78 Women=113 Age= 85 years Design= Cross-sectional	Home type, functional ability (Mob-H Scale) Cognitive ability (MMSE score)	Coronal caries (DFS* index) Root caries (RCI* index)	Gender, number of teeth, self-rated health and health behavior	Individuals with functional decline and cognitive impairment had higher level of active coronal caries and active root caries compared with subjects with no functional decline or cognitive impairment
Avlund *et al.* (2004)	N=159 Design= Cross-sectional	Cognitive ability measured by MMSE score Function ability measured by change in functional ability which was measured through the change of function from first follow-up of the parent study till this study, IADL activities measured by need of help in	Coronal and root caries, number of teeth, use of dental services	Age, gender, level of school education	Participants with low MMSE score were at higher risk of coronal caries and were at 4 times higher risk of not using dental services. Mild cognitive decline with a

		laundry, housework and shopping			decrease in functional ability was a risk factor for root caries.
Morishita *et al.* (2001)	N=668 home bound elderly Male= 211 Female= 450 Mean Age= 81.7 years Design= Cross-sectional	ADL scale, Independence of daily oral hygiene and meal	Frequency of tooth brushing, use of dentures, diet, use of dental services	-	Individuals with higher ADL displayed better oral hygiene and diets as compared to subjects with low ADL.
Avlund *et al.* (2001)	N=326 Age:75-80 Design= Longitudinal	Functional ability at age 75 and age 80 measured by (Mob-T and Mob-H scale), Changes in functional ability from age 75 to age 80 measured as (improved or sustained good function, decreased function, sustained poor function)	Oral health was measured by self-reported number of teeth and chewing ability and use of dental services	Gender, chronic diseases, self-rated health, sociodemographic factors, living alone and social relations.	Old persons with poor functional ability were at higher risk of having no or few teeth, had more chewing difficulties, and were not visiting the dentist or denturist on a regular basis.
Jette *et al.* (1993)	N=1,156 Age= ≥70 Design= Cross-sectional	Mobility disability Personal care disability (ADL score)	Current decay, edentulism, periodontal disease >4mm pocket	Age, gender, years of formal education, living condition, oral hygiene practices, most recent dental visits	Older people with disabilities were at increased risk of tooth decay and edentulism, there was no significant relationship between physical disability and periodontitis.

*DT=decayed teeth, DFT= decayed and filled teeth, DMFT= decayed, missing and filled teeth, MMSE= mini mental scale examination, GDS= geriatric depression scale, DFS= decayed and filled surfaces, RCI= root caries index, ADL= activities of daily living, IADL= instrumental activities of daily living.

3 AIM OF STUDY

3.1 General aim:

To determine whether the functional ability is a predictor of oral health in a longitudinal setting

3.2 Specific aim:

To determine whether ADL and IADL predict the number of decayed teeth and number of teeth with deepened periodontal pockets ≥4mm in a sample of adult Finnish population in a longitudinal setting.

4 METHODOLOGY

4.1 Study population

The study used the data from the Health 2000 and Health 2011 Surveys in Finland (Heistaro 2008, Lundqvist & Mäki-opas 2016). Both the surveys were approved by the Ethics Committee for Epidemiology and Public Health of the Hospital District of Helsinki and Uusimaa. Besides, written informed consent was taken from all the participants of the survey.

4.1.1 The Health 2000 Survey

The Health 2000 Survey was conducted in 2000 and 2001. The target population was individuals aged 18 or over and living in mainland Finland. The study design was two-stage stratified sampling. The final sample size was 9992 for the survey of whom 8028 were aged 30 and above and were included in the main survey. The remaining 1894 were included in the study of young adults. Data were collected in the form of interviews, questionnaires, measurements (blood pressure and heart rate, height, body circumference, and others), blood samples and clinical examinations. Data on key characteristics of each person were obtained from the National Population Register. In addition, administrative register data were obtained with specific permissions from the institutes responsible for each register. The main focus of the study was the major public health problems and functional capacity with special emphasis placed on, cardiovascular and respiratory diseases, musculoskeletal and mental disorders and oral health (Heistaro 2008).

A large number of interview questions were related to functional capacity. Questions regarding activities of daily living (ADL) and instrumental activities of daily living (IADL) were asked from the respondents. Many of these questions were based on items developed by Katz index of activity of daily living, Lawton and Brody instrumental activities of daily living scale (Katz *et al.* 1963, Lawton & Brody 1969, Katz *et al.* 1970) and on the Organisation for Economic Co-operation and Development (OECD) recommendations (McWhinnie 1981) (Heistaro 2008).

Information regarding oral health was collected during health interviews, questionnaire, and clinical and radiographic examinations. The oral health interview covered questions concerning self-reported oral health status, oral self-care and use of oral health care services.

The questionnaire included questions about problems related to oral health. A detailed clinical oral health examination of 6335 subjects was conducted including radiographs for 6005. A short clinical oral examination, which includes the information on the number of teeth and use of removable denture was also conducted at home for those people who did not attend the health examination (Heistaro 2008).

4.1.2 The Health 2011 Survey (Follow-up survey)

The main aim of the Health 2011 Survey was to obtain knowledge regarding the current health and functional capacity of the working-aged and elderly Finnish population. The survey design was both cross-sectional and longitudinal. In the Health 2011 Survey, the participants who took part in the Health 2000 Survey were re-invited to reproduce a representative longitudinal data on the Finnish adult population. Data were collected in the form of four questionnaires, health examination, clinical measurements, blood samples, and health interview. Phone interviews were offered to subject not willing to participate or who were unable to participate in the health examination or the concise health examination at home. Like in the Health 2000 Survey, data on key characteristics of each person were obtained from the National Population Register. Also, administrative register data were obtained with specific permissions from the institutes responsible for each register (Lundqvist & Mäki-opas 2016).

Information on oral health was collected through interviews and questionnaires from the whole sample but the clinical oral health examinations were carried out only in two field examination areas, i.e. the southern and northern areas (Helsinki and Oulu), and the radiographic examination was carried out only in Helsinki. A total of 3938 subjects were invited to participate in clinical oral health examinations. Participation rate in clinical oral health examination was 41% of which 38% was from southern and 45% from northern Finland (Suominen *et al.* 2018). The oral health interview covered questions concerning self-reported oral health status, oral self-care and use of oral health care services and the questionnaire included questions about problems related to oral health (Lundqvist & Mäki-opas 2016).

4.2 Study design and participants

This study included only those participants who participated in clinical oral examination and answered questions regarding functional ability during the interview in both the Health 2000

and Health 2011 Surveys and were over 30 years old at the time of the survey. Hence, the total number of participants for this study were 1225.

The data of functional capacity (ADL and IADL) were taken at baseline from the Health 2000 Survey and the participants were followed up to see the longitudinal association of functional capacity and oral health particularly differences in the number of decayed teeth and teeth with deepened periodontal pockets (≥ 4mm) in 2011. The data on decayed teeth and teeth with deepened periodontal pockets (≥ 4mm) were taken from Health 2000 and Health 2011 Surveys (See figure 4).

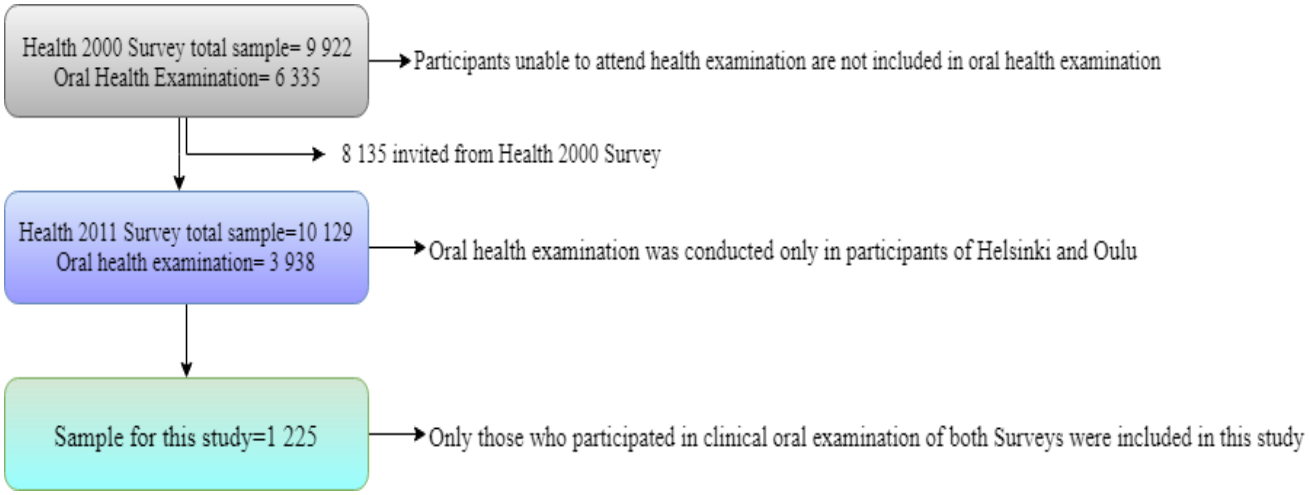

Figure 4. Selection of participants for the present study (Partly modified from Heistaro 2008, Lundqvist & Mäki-opas 2016)

4.3 Outcomes

The protocol for clinical oral examination was the same in both the Health 2000 and Health 2011 Surveys. The oral health examination team comprised of a dentist and a dental nurse. Equipment used to check the condition of teeth and detection of caries and periodontitis were: portable dental treatment unit, portable patient chair, fibre optic light (Novar®), fibre optic headlamp (Tekmala Oy), a letter scale, mouth mirror and a WHO periodontal probe with a ball end (Plandent Oyj, no. 19577) (Vehkalahti *et al.* 2008, Lundqvist & Mäki-Opas 2016).

The criteria for the detection of caries was dentine lesion that was extensive enough to require treatment with filling. Furthermore, those teeth, which showed cavitated carious lesion that had penetrated fissures and had already undermined enamel surface or had extended into dentine so that dentine walls were showing signs of softening were also marked as decayed. The tooth was not recorded as carious if there was any uncertainty in the observation. The

tooth was recorded as having coronal or root caries or both based on the location of caries (Vehkalahti *et al.* 2008). In the analysis, the number of decayed teeth per person was calculated and used as an outcome variable.

Periodontal health was assessed by probing all teeth at four points' i.e. distal corner and midpoint of buccal surface, and midpoint and mesial corner of the lingual surface with WHO periodontal probe with ball end, using 20g force. The deepest pocket depth for each tooth was noted. Periodontal pockets were measured in millimeters and were categorized into: "no periodontal pocket", "4–6 mm deep periodontal pocket" and "6 mm or deeper periodontal pocket" (Knuuttila & Suominen-Taipale 2008). In the analysis, the number of teeth with deepened periodontal pockets (≥ 4mm) per person was calculated and used as an outcome variable.

4.4 Exposures

Functional ability i.e. ADL was measured through an interview consisting of 9 questions. In the interview, activities of daily living were originally assessed by asking the participants how they can manage the following activities like getting in and out of bed, dressing and undressing, cutting toenails, eating, washing yourself, toileting, using phone, taking care of matters together with other people and presenting matters to unknown people. All these questions were based on the Katz Index of Activities of Daily Living (ADL) (Katz *et al.* 1963, Katz *et al.* 1970) and OECD recommendations (McWhinnie 1981). Instrumental activities of daily living were measured by asking about the ability to perform the following tasks: shopping, cooking, laundry, heavy cleaning, carrying shopping bag or some other load of 5 kilos for 100 meters and handling matters in public offices. These questions were based on Lawton and Brody Instrumental Activities of Daily Living (IADL) scale (Lawton & Brody 1969) and OECD recommendations (McWhinnie 1981).

For the ADL, each question had 4 answering options i.e. with no difficulty, with minor difficulty, with major difficulty and not at all. In the Katz index of ADL, participants were given a score of 1 and 0 depending upon their ability to perform these tasks, i.e. if a person was able to perform the task, he/she will get score 1 otherwise 0. In this study, we tried to recode the variables according to Katz index i.e. people with no difficulty or minor difficulty as 1 and participants with major difficulty and not able to perform as 0 but almost all participants of clinical oral examination had no or only minor difficulty in performing these tasks. If re-coded as mentioned above, all of them would get a score of 1. Hence, to see the

difference among groups, the answering options were re-coded and given a score of 1 and 0 according to the following: with no difficulty=1 and with minor, major difficulty or inability=0.

For the IADL, responses were categorized into four categories: no difficulties, minor difficulties, major difficulties and not able to perform (Lundqvist & Mäki-Opas 2016). In the original scale of IADL, designed by Lawton and Brody all the questions were scored either 0 or 1 depending upon the ability to perform the task. To perform analysis in this study, the answering options measuring IADL were re-coded similarly as ADL i.e. with no difficulty=1 and with minor, major difficulty or inability=0.

4.5 Covariates

Age, gender, Body Mass Index (BMI), level of education, marital status, smoking, alcohol consumption, use of sugar in tea/coffee, use of medications, perceived health, tooth brushing frequency, use of habitual dental services, and number of teeth with plaque were included as covariates.

Sociodemographic and socioeconomic factors included age, gender, marital status, and education. Data for age, gender, marital status, and education were obtained through interviews. Age was used both as a continuous and categorical variable. From Health 2000 Survey age was categorized into 4 groups' i.e. 30-44, 45-54, 55-64 and 65+ years. In 2011, according to distribution in Health 2011 Survey, from 40-54, 55-64, 65-74, and 75+. Information on marital status and education were obtained through interview. Marital status was categorized into following: married, living with your partner, divorced or living apart, widowed and single. Answering options one and two as well as three and four were combined to form three categories: married or cohabiting, divorced or widow and single. Data on education were classified into three categories: basic (those who did not complete high school and those with no formal vocational qualification), intermediate (who completed high school or formal vocational education) and higher (university or polytechnic graduates).

Behavioral factors included smoking, alcohol consumption and the use of sugar in tea/coffee. Data for smoking were obtained through interview. Smoking was categorized into non-regular use and regular use. Data for alcohol consumption and the use of sugar in tea/coffee were obtained through a questionnaire. Consumption of alcohol was determined by asking "how often have you drunk alcoholic drinks during the past 12 months"? The answering options

were: not once, 6 to 7 times a week, 4 to 5 times a week, 2 to 3 times a week, once a week, a couple of times a month, approximately once a month, approximately once every two months, 3 to 4 times a year and a couple of times a year. Answering options one, eight and nine were combined. Similarly, options six and seven, four and five, as well as one and two, were combined to form five categories: never, once a month or less, 2-4 times a month, 2-3 times a week and four times or more per week. The use of sugar in tea/coffee was categorized into 3 times a day or more often, once or twice a day, 2 to 5 times a week and more rarely or never. Answering options one, two and three, as well as four and five, were combined to form two categories: daily and never.

Oral hygiene and dental behavior included the occurrence of dental plaque, tooth brushing frequency and use of habitual dental services. Dental plaque was measured during clinical oral examination by a scale which was modified from the one developed by Silness and Löe in 1964. The plaque was measured from one surface of three different teeth i.e. the labial surface of the left lower canine, the lingual surface of the last tooth in the lower left quadrant and the buccal surface of the last tooth in the upper right quadrant of the dental arch (Silness & Löe 1964). The observations were categorized into following: no plaque, gingival plaque only and gingival and other plaque. In Health 2011 survey, slight modifications were made in the measurement of plaque. The plaque was measured on the buccal surface of all teeth except for third molars. The observations were recorded in two categories: no plaque and any plaque.

Tooth brushing frequency and use of habitual dental services were measured by interviewing the participants. Tooth brushing frequency was asked as “how often do you usually brush your teeth”. The response options were: more often than twice a day, twice a day, once a day, less frequently than every day, and never. Response options one and two, as well as four and five, were combined to form three categories: twice a day, once a day and occasionally. The question regarding the use of habitual dental services was “do you usually go to a dentist”. The options were: regularly for a checkup, only when you have a toothache or some other trouble and never. These options formed three categories: regular, sometimes and never.

Information regarding perceived health and use of medications were obtained through the interview. The question for perceived health was “What is your current health status”? The response options were: good, rather good, moderate, rather poor and poor. Options one and two, as well as four and five, were combined to form three categories: good or fairly good, average, fairly bad or poor. Use of lipid-lowering drugs, systemic corticosteroids, anti-inflammatory drugs, and multi analgesics NSAIDs was categorized into: yes and no.

Body Mass Index (BMI) was used as a continuous variable in data analysis. The information for BMI was obtained mostly through measuring the height and weight of an individual during a clinical health examination. In some cases, BMI values were obtained from the self-report, questionnaire and through bioimpedance test.

4.6 Statistical analysis

Data were processed and analyzed by SPSS 23. Predicting variables were ADL and IADL at baseline and outcome variables were the number of decayed teeth and the number of teeth with deepened periodontal pockets ≥ 4mm in 2011. Mann-Whitney U test and Poisson Regression analysis were performed to analyze the data.

Mann-Whitney U test was used to compare the differences in the mean number of decayed teeth and mean number of teeth with deepened periodontal pockets ≥ 4mm according to the difficulty in performing ADL or IADL (Tables 5, 6).

Poisson regression analysis could not be performed for ADL because of the distribution (i.e. small sample size of participants having difficulty in performing ADL) of separate ADL questions. However, Poisson regression analysis was performed for IADL. Separate models were performed for associating each task in IADL with the number of decayed teeth and teeth with deepened periodontal pockets ≥4mm. The number of teeth in 2011 was used as an offset variable. The results were obtained in terms of the Incidence rate ratio (IRR). The adjusted IRR and 95% confidence intervals (CI) were presented only for the activities with sample size ≥20 to avoid chance finding and need of multiple testing in the group of people having difficulties in IADL in tables 7 and 8. Poisson regression analysis for age ≥55 was also not presented in the results because of the sample size smaller than 20 in the group of people having any difficulties in IADL.

The associations between the exposure and outcome variables were adjusted for various covariates using Poisson regression analysis. Following modeling strategy was used in order to understand the effect of covariates on the association:

- Model 1: Adjusted for age and gender
- Model 2: Model 1+ level of education, marital status
- Model 3: Model 2+ smoking, alcohol consumption, use of sugar in tea/coffee, perceived health, use of medications (lipid-lowering drugs, systemic corticosteroids, anti-inflammatory, and NSAID's) and BMI.

- Model 4: Model 3+ tooth brushing frequency, use of habitual dental services and number of teeth with plaque.

5 RESULTS

According to table 2, the average age of participants in 2000 was 47.9 and in 2011 58.9. On average, the number of teeth was higher in 2000 as compared to 2011. There was a small increase in the mean number of decayed teeth and a mean number of teeth with deepened (≥4mm) periodontal pockets in 2011 as compared to 2000. The number of people practicing dental hygiene increased over 11 years. During the same period, we also observed an increase in BMI and the use of alcohol and a decrease in regular smoking (Table 2).

Table 2. Characteristics of study population; The Health 2000 and Health 2011 Surveys (n=1225)

Characteristics of study population	In 2000			In 2011	
	n	%		n	%
Sociodemographic and socioeconomic variables					
Age(years)			Age(years)		
30-44	529	43.2	40-54	491	40.1
45-54	359	29.3	55-64	363	29.6
55-64	232	18.9	65-74	251	20.5
65+	105	8.6	75+	120	9.8
Gender					
Male	544	44.4		544	44.4
Female	681	55.1		681	55.1
Level of education					
Basic	300	24.6		284	23.4
Intermediate	397	32.5		368	30.3
Higher	523	42.9		563	46.3
Marital status					
Married	934	76.6		889	73.2
Widow/ divorced	154	12.6		217	17.9
Single	132	10.8		109	9.0
Behavioral factors					
Smoking					
Non-regular use	982	80.5		1048	86.3
regular use	238	19.5		166	13.7
Alcohol consumption					
Never	290	23.9		188	15.5
Once a month or less	181	14.9		296	24.4
2 to 4 times a month	460	37.9		421	34.7
2 to 3 times a week	215	17.7		238	19.6
4 or more a week	69	5.7		70	5.8
Sugar in tea/coffee					
Daily	721	60.2		734	61.9
Never	476	39.8		452	38.1
Oral hygiene and dental behavior					
Use of habitual dental services					
Regular	697	63.7		770	63.5
Sometimes	391	35.7		395	32.6
Never	7	0.6		47	3.9

Tooth brushing frequency				
Twice a day	766	70.0	895	73.8
Once a day	290	26.5	284	23.4
Occasionally	39	3.6	34	2.8
Number of teeth with plaque				
None	404	36	(Mean/SD)	
Marginal	604	3.8	3.9 ±5.0	
Elsewhere	114	10.2		
Perceived health and use of medications				
Perceived health				
Good or fairly good	899	73.9	937	77.1
Average	265	21.8	209	17.2
Fairly bad or poor	53	4.4	69	5.7
Use of medications				
Lipid lowering drug				
No	1070	94.8	993	81.7
Yes	59	5.2	223	18.3
Systemic corticosteroids				
No	1109	98.2	1201	98.8
Yes	20	1.8	15	1.2
Anti-inflammatory				
No	674	59.7	1110	91.3
Yes	455	40.3	106	8.7
Multi-analgesics NSAIDs*				
No	959	84.9	1160	95.4
Yes	170	15.1	56	4.6
Other characteristics				
	Mean	**SD**	**Mean**	**SD**
Age(years)	47.9 ±11.3		58.9 ± 11.3	
BMI*	26.3 ± 4.4		27.2 ± 4.8	
MMSE score*	14.3±1.7		13.5±2.2	
Number of teeth	22.8 ± 9.1		21.7±9.3	
Number of decayed teeth	0.4 ± 1.5		0.4 ± 1.5	
Number of teeth with deepened periodontal pockets (≥4mm)	4.2 ± 5.6		4.6 ± 5.7	

*MMSE score=Mini mental state examination score, BMI= Body mass index, kg/m², NSAIDs= Non-steroidal anti-inflammatory drugs.

Tables 3 and 4 show the distribution of ADL and IADL variables. It can be observed that more than 90% of the participants of this study had no difficulty in performing ADL and IADL. Among tasks related to ADL, there were only a few people who were unable to cut their toenails or present matters to unknown people completely.

Table 3. Distribution of tasks included in the Activities of Daily Living (ADL).

Activities of Daily Living	Whole study population (n=1225)		Population ≥ 55 years in 2000 (n=337)	
	n	%	n	%
Getting in and out of bed				
With no difficulty	1195	98.0	322	95.8
With minor difficulty	25	2.0	14	4.2
Dressing and Undressing				
With no difficulty	1197	98.1	326	97.0
With minor difficulty	23	1.9	10	3.0
Cutting your toenails				
With no difficulty	1184	97.1	312	93.1
With minor difficulty	22	1.8	16	4.8
With major difficulty	9	0.7	4	1.2
Not at all	4	0.3	3	0.9
Eating				
With no difficulty	1216	99.7	336	100
With minor difficulty	4	0.3	0	0
Washing yourself				
With no difficulty	1210	99.2	334	99.4
With minor difficulty	10	0.8	2	0.6
Going to the toilet				
With no difficulty	1214	99.6	336	100
With minor difficulty	5	0.4	0	0
Using the phone				
With no difficulty	1214	99.6	335	99.7
With minor difficulty	4	0.3	1	0.3
With major difficulty	1	0.1	0	0
Taking care of matters together with other people				
With no difficulty	1210	99.3	332	98.8
With minor difficulty	6	0.5	3	0.9
With major difficulty	3	0.2	1	0.3
Presenting matters to unknown people				
With no difficulty	1203	98.7	333	99.1
With minor difficulty	14	1.1	2	0.6
With major difficulty	1	0.1	1	0.3
Not at all	1	0.1	0	0

Table 4. Distribution of tasks included in the Instrumental Activities of Daily Living (IADL).

Activities of Daily Living	Whole study population (n=1225)		Population ≥ 55 years in 2000 (n=337)	
	n	%	n	%
Shopping				
With no difficulty	1206	98.9	329	97.9
With minor difficulty	3	0.8	4	1.2
With major difficulty	1	0.2	2	0.6
Not at all	10	0.1	1	0.3
Cooking				
With no difficulty	1187	97.3	320	95.2
With minor difficulty	23	0.2	14	4.2
With major difficulty	28	0.3	0	0
Not at all	2	0.3	2	0.6
Laundry				
With no difficulty	1189	97.5	320	95.2
With minor difficulty	24	2.0	12	3.6
With major difficulty	3	0.2	2	0.6
Not at all	4	0.3	2	0.6
Heavy cleaning, e.g. carrying and beating of carpets or washing windows?				
With no difficulty	1111	91.1	270	80.4
With minor difficulty	71	5.8	42	12.5
With major difficulty	23	1.9	14	4.2
Not at all	15	1.2	10	3.0
Banking, handling matters in public offices or similar				
With no difficulty	1202	98.6	328	97.6
With minor difficulty	12	1.0	6	1.8
With major difficulty	3	0.2	2	0.6
Not at all	2	0.2	0	0
Carrying a shopping bag or some other load weighing about 5kg for at least 100 meters				
With no difficulty	1141	93.6	285	85.1
With minor difficulty	52	4.3	32	9.6
With major difficulty	10	0.8	8	2.4
Not at all	16	1.3	10	3.0

We observed no statistically significant difference in the mean number of decayed teeth and teeth with deepened periodontal pockets ≥ 4mm among participants who experienced any difficulty in performing ADL as compared to those who had no difficulty. However, a statistically significant difference was observed only in the mean number of decayed teeth among participants who had difficulties cutting toenails ($p<0.05$) (Table 5). Moreover, we also observed that participants who had any difficulty in performing some tasks of ADL had a smaller number of decayed teeth and teeth with deepened periodontal pockets ≥ 4mm as compared to those who had no difficulty. However, the difference was not statistically significant.

Among the tasks related to IADL, there were statistically significant differences in the mean number of teeth with deepened periodontal pockets ≥ 4mm between participants who had any difficulties in cooking food or doing laundry and participants without any difficulty. Similarly, the mean number of decayed teeth was clearly higher in participants who had any difficulties in doing laundry and carrying a shopping bag or some other load weighing about 5kg for at least 100 meters ($p<0.01$) (Table 6).

Table 5. Mean number of decayed teeth and teeth with deepened periodontal pockets ≥4mm in 2011 according to the tasks included in the Activities of Daily Living (ADL) in 2000, n=1225

Activities of daily living	Number of decayed teeth		Number of teeth with deepened periodontal pockets ≥ 4mm	
	Mean	SD	Mean	SD
Getting in and out of bed				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.6	1.4	5.0	5.0
p-value	**0.207***		**0.411***	
Dressing and undressing				
With no difficulty	0.4	1.4	4.8	5.6
With any difficulty	0.2	0.5	4.6	5.7
p- value	**0.708**		**0.686**	
Cutting your toenails				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.7	1.1	3.1	4.0
p- value	**0.036**		**0.456**	
Eating				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.2	0.5	6.2	4.9
p- value	**0.869**		**0.384**	
Washing yourself				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.3	0.6	6.1	6.1
p- value	**0.986**		**0.282**	
Going to the toilet				
With no difficulty	0.4	0.4	4.6	5.7
With any difficulty	0.2	1.4	6.0	4.3
p- value	**0.942**		**0.306**	
Using the phone				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.0	0.0	6.0	4.3
p- value	**0.272**		**0.306**	
Taking care of matters together with other people				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	1.0	1.6	6.8	3.5
p- value	**0.287**		**0.099**	
Presenting matters to unknown people				
With no difficulty	0.4	1.4	4.6	5.8
With any difficulty	0.6	1.1	6.9	5.7
p- value	**0.158**		**0.062**	

*Results of Mann Whitney U test, p-value <0.05

Table 6. Mean number of decayed teeth and number of teeth with deepened periodontal pockets(≥4mm) in 2011 according to the task included in Instrumental Activities of Daily Living (IADL) in 2000, n=1225

Instrumental activities of daily living	Number of decayed teeth		Number of teeth with deepened periodontal pockets ≥ 4mm	
	Mean	**SD**	**Mean**	**SD**
Shopping				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.7	1.2	5.1	4.2
p-value	**0.219***		**0.410***	
Cooking				
With no difficulty	0.4	1.4	4.5	5.7
With any difficulty	0.9	1.8	6.6	6.4
p-value	**0.055**		**0.050**	
Laundry				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.8	0.7	6.7	5.6
p-value	**0.009**		**0.022**	
Heavy cleaning, e.g. carrying and beating of carpets or washing windows?				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.7	1.2	7.0	5.2
p-value	**0.646**		**0.665**	
Banking, handling matters in public offices or similar				
With no difficulty	0.4	1.4	4.6	5.7
With any difficulty	0.7	1.2	7.0	5.2
p-value	**0.111**		**0.073**	
Carrying a shopping bag or some other load weighing about 5kg for at least 100 meters				
With no difficulty	0.4	1.4	4.6	5.8
With any difficulty	0.7	1.5	4.2	5.0
p-value	**0.007**		**0.695**	

*Results of Mann Whitney U test, p-value <0.05

In Model 1 adjusted for age and gender, there was a statistically significant association between an inability to perform instrumental activities of daily living (IADL) tasks and a higher number of decayed teeth except for the inability to cook food. After adjusting additionally for education and marital status in model 2, the results remained statistically significant for all tasks. In model 3, the result remained the same as model 1 after adjusting for all variables except oral hygiene and dental behavior. In a more comprehensively adjusted model (Model 4), the inability to perform all tasks of IADL was significantly associated with a higher number of decayed teeth except for cooking food (Table 7).

Poisson regression analysis adjusted for age and gender in model 1(Table 8) also revealed statistically significant associations between an inability to perform instrumental activities of daily living (IADL) tasks and a higher number of teeth with deepened periodontal pockets ≥4mm except for the inability to cook and walk 100 meters with 5kg of weight. However, inability to perform IADL was significantly associated with the higher number of deepened periodontal pockets ≥4mm in model 2, 3 and 4 after adjusting for further covariates in each model (Table 8), except for the inability to walk 100 meters with 5kg of weight. The inability to walk 100 meters with 5kg of weight was statistically significantly associated with a decreased number of teeth with deepened periodontal pockets ≥4mm.

Table 7. Association of tasks included in the Instrumental Activities of Daily Living (IADL) in 2000 with number of decayed teeth in 2011 among whole study population. Separate models for each task.

Inability to do	Model 1 (n=1119)			Model 2 (n=1024)			Model 3 (n=1013)			Model 4 (n=972)		
	IRR[1]	95% CI[2]	p-value	IRR[1]	95% CI[2]	p-value	IRR[1]	95% CI[2]	p-value	IRR[1]	95% CI[2]	p-value
Cook food [3]	1.1	0.7-1.7	0.556	1.8	1.2-2.8	0.003	1.3	0.8-2.2	0.238	1.3	0.8-2.2	0.210
Laundry [3]	2.2	1.4-3.4	<0.001	5.4	3.4-8.4	<0.001	5.9	3.7-9.4	<0.001	4.8	2.9-8.1	<0.001
Heavy cleaning [3]	5.2	3.4-7.8	<0.001	4.2	2.8-6.4	<0.001	4.5	2.8-7.1	<0.001	2.3	1.4-3.7	0.001
Walking 100 meters with 5kg weight[3]	3.4	2.3-4.9	<0.001	1.6	1.1-2.3	0.012	2.7	1.8-4.2	<0.001	3.0	2.0-4.6	<0.001

[1]IRR= Incidence Rate Ratio, [2]CI= Confidence Interval
[3]with any difficulty, reference: without difficulty
Model 1: Adjusted for age, gender
Model 2: Model 1+ level of education, marital status
Model 3: Model 2+ smoking, alcohol consumption, use of sugar in tea / coffee, perceived health, use of medications (lipid- lowering drugs, systemic corticosteroids, anti-inflammatory and multi analgesics NSAID's and Body Mass Index
Model 4:Model 3+tooth brushing frequency, use of habitual dental service ,number of teeth with plaque

Table 8. **Association of tasks included in Instrumental Activities of Daily Living (IADL) in 2000 with number of teeth with deepened periodontal pockets ≥4mm teeth in 2011. Separate models for each task.**

Inability to do	Model 1 (n=1086)			Model 2 (n=1086)			Model 3 (n=976)			Model 4 (n=946)		
	IRR[1]	95% CI[2]	p-value	IRR[1]	95% CI[2]	p-value	IRR[1]	95% CI[2]	p-value	IRR[1]	95% CI[2]	p-value
Cook food [3]	1.1	0.9-1.2	0.212	1.2	1.0- 1.4	0.012	1.8	1.5-2.2	<0.001	1.5	1.3-1.8	<0.001
Laundry [3]	1.9	1.6-2.2	<0.001	2.9	2.4-3.4	<0.001	3.2	2.7-3.8	<0.001	3.3	2.8-4.0	<0.001
Heavy cleaning[3]	5.3	4.7-5.9	<0.001	4.9	4.4-5.5	<0.001	4.0	3.5-4.6	<0.001	2.6	2.2-3.0	<0.001
Walking 100 meters with 5kg weight[3]	1.0	0.9-1.2	0.535	0.5	0.4-0.6	<0.001	0.6	0.5-0.7	<0.001	0.6	0.5-0.7	<0.001

[1]IRR= Incidence Rate Ratio, [2]CI= Confidence Interval
[3]with any difficulty, reference: without difficulty
Model 1: Adjusted for age, gender
Model 2: Model 1+ level of education, marital status
Model 3: Model 2+ smoking, alcohol consumption, use of sugar in tea / coffee, perceived health, use of medications (lipid- lowering drugs, systemic corticosteroids, anti-inflammatory and multi analgesics NSAID's and Body Mass Index
Model 4:Model 3 + tooth brushing frequency, use of habitual dental services, number of teeth with plaque

6 DISCUSSION

6.1 Principal findings

This study found no statistically significant differences in oral health among participants having difficulties in functional ability using Activities of Daily Living (ADL). However, the functional ability was associated with oral health using the Instrumental Activities of Daily Living (IADL).

There was no statistically significant difference in the average number of decayed teeth among participants incapable to perform ADL as compared to those who had no difficulty in ADL. However, a statistically significant difference was seen only in participants who were unable to cut their toenails. Nevertheless, the study found a statistically significant positive association between IADL i.e. inability to perform laundry, heavy cleaning and walking 100 meters with 5kg weight and a higher number of decayed teeth among the whole study population.

The study found no statistically significant difference in deep periodontal pockets ≥ 4mm among participants who had difficulty in functional ability using ADL, as compared to those who had no difficulty. However, there was a statistically significant association between functional ability and oral health using IADL. Participants who were unable to do cooking, laundry and heavy cleaning had increased risk of deepened periodontal pockets ≥ 4mm as compared to those having no difficulty. In addition, the inability to walk 100 meters with 5kg weight, unexpectedly found to have a protective effect against the risk of deepened periodontal pockets ≥4mm.

6.2 Study findings relative to previous studies

Several studies have pointed out the fact that the risk of oral diseases increases with old age. One of the reasons for this is poor functional capacity and decreased cognitive ability (Avlund *et al.* 2001, Sánchez-García *et al.* 2011, Philip *et al.* 2012, Antunes *et al.* 2017). Several cross-sectional studies aimed to determine the association between functional ability and oral health and found a positive association between decreased functional ability with poor oral health. A study conducted by Avlund *et al.* (2001) suggested that older people with poor functional capacity use dental services less frequently, have a smaller number of teeth and have more difficulty in chewing food (Avlund *et al.* 2001). Another study by Philip *et al.* (2012) found a positive association between disability, which regards as poor functional capacity, and a higher risk of caries (Philip *et al.* 2012). Another study by Sánchez-García *et al.* suggested that persons who have difficulties in ADL and IADL are at increased risk of developing root caries (Sánchez-García *et al.* 2011).

The present study focused on decayed teeth and teeth with deepened periodontal pockets ≥4mm as an indicator of poor oral health among the Finnish adult population. Periodontitis and dental Caries are one of the most prevalent chronic diseases worldwide (WHO 2017). Periodontitis is also one of the most common oral health problems among the Finnish population.

Unlike other studies, this study could not find statistically significant differences in the oral health of individuals according to functional ability using a mean number of decayed teeth and ADL as an indicator of oral health and functional ability. However, the only statistically significant difference was found for participants who were unable to cut their toenails. Differences in results might be due to the difference in the study population. Most of the participants of this study had no difficulty or only minor difficulty in performing tasks related to activities of daily living which can partly explain the difference in results. Also, according to Aromaa & Koskinen (2004), the majority of the Finnish population have good functional capacity, and only after the age of 85 years, have problems in activities of daily living along with sensory and cognitive decline. This can also explain no statistically significant difference in the number of decayed teeth according to functional capacity using ADL. In addition, most of the previous studies, which associated reduced functional ability with a higher risk of decayed teeth used study participants having dementia and participants from nursing home residents. A study conducted by Ellefsen *et al.* (2008) concluded that patients with dementia were more prone to coronal and root caries as compared to participants without dementia (Ellefsen *et al.* 2008). However, present study also included participants who were adults having no dementia. Another study by Philip *et al.* (2012) found a positive association between reduced functional ability and the risk of decayed teeth. However, the study used Activities of Daily Living Oral Health (ADLOH) scale instead of Katz index of ADL, which can only analyze difficulty in performing tasks related to oral health such as brushing, flossing, topical fluoride application and oral rinses (Philip *et al.* 2012, Bauer *et al.* 2001). In addition, the ADLOH scale is not validated and less commonly used scale. The only study that found a positive association between reduced ADL and risk of decayed teeth among general population was conducted by Jette *et al.* (1993), which concluded that physical disabilities in activities such as eating, bathing, and toileting that require fine motor skills were strongly associated with current dental caries. But, this study was cross-sectional in design (Jette *et al.* 1993).

The present study found that poor functional capacity (IADL) i.e. inability to perform laundry, heavy cleaning and walking 100 meters with 5kg weight is a risk factor for poor oral health using decayed teeth as an indicator of poor oral health. According to Antunes *et al.* (2017), the process of functional disability starts with mild or moderate difficulty in mobility, followed by difficulty in

instrumental activities of daily living which makes it difficult to access dental care services and affects oral health. This explains the association of IADL with the risk of decayed teeth. In addition, in Model 4 after adjusting for oral hygiene and dental behavior, risk of decayed teeth reduced to half for participants unable to perform heavy cleaning task which indicates that oral hygiene i.e. plaque and oral hygiene behavior (tooth brushing frequency and use of habitual dental services) acts as a mediator in association between heavy cleaning and number of decayed teeth. The results are also in line with a study conducted by Avlund *et al.* (2004) that concluded that those who needed help in laundry were at higher risk of coronal and root caries (Avlund *et al.* 2004). Study conducted by Chalmers *et al.* (2002) also found a positive association between functional inability (ADL and IADL) and risk of coronal and root caries, however, the study was based on nursing home residents who were functionally very dependent, cognitively impaired, behaviorally difficult and medically compromised older adults (Chalmers *et al.* 2002).

Similar to the study conducted by Jette *et al.* (1993), this study could not find any differences in the mean number of teeth with deepened periodontal pockets ≥4mm according to the level of functional capacity using ADL.

The present study concluded a positive association between functional capacity and oral health using IADL and the number of teeth with deepened periodontal pockets ≥4mm as an indicator of functional capacity and oral health. Some tasks related to IADL for instance, inability to do cooking, laundry and heavy cleaning were positively associated with an increased mean number of teeth with deepened periodontal pockets ≥4mm. Moreover, similar to the association of heavy cleaning with the number of decayed teeth, oral hygiene and dental behavior act as a mediator in an association of inability to do heavy cleaning and risk of deep periodontal pockets ≥4mm. The results are also in line with the study conducted by Yu *et al.* (2011) that found a positive association between difficulties in IADL and the risk of severe periodontitis (Yu *et al.* 2011). However, in this study inability to walk 100 meters with 5kg weight was oddly found to be protective against the risk of deepened periodontal pockets, which means that those who were unable to walk 100 meters with 5kg weight, were at a decreased risk of deepened periodontal pockets ≥4mm. This contradictory result might be because 85% of the participants unable to walk 100 meters with 5kg were females. According to Suominen and colleagues (2008), Finnish women have better oral hygiene habits than men. Secondly, those participants had on average fewer number of teeth with plaque than participants who had difficulty in any other IADL task.

6.3 Strengths and weaknesses

The longitudinal design of the study is its utmost strength. Previous studies associating functional ability and oral health were mostly conducted on institutionalized elderly people, people with cognitive problems and patients with Alzheimer's disease. Moreover, most of the previous studies that were conducted on participants with intact cognitive function were performed on home-dwelling elderly people. Therefore, this study is representative of the general population including community-dwelling as well as institutionalized young, middle-aged and elderly people.

The study considered several, e.g. sociodemographic, behavioral and other confounding variables used in previous studies and have adjusted for additional confounders in data analysis, which reduced the risk of bias. This study has analyzed the entire task in Lawton & Brody's IADL scale separately; this has given an added advantage in not only associating IADL with caries and periodontitis but also identifying the specific tasks, which are sensitive to determine functional limitation in people.

Overall participation rate in the Health 2011 Survey was low as compared to the Health 2000 Survey. Participation rate in the Health 2011 Survey clinical oral examination was 41% i.e. 38% in the southern and 45% in the northern part of Finland. The follow-up clinical oral examination was conducted only in the southern and northern parts of Finland therefore; the final sample size was small and may not be representative of the entire population. This weakness in data collection might have affected the results.

Moreover, the participants who were unable to attend clinical oral examination due to difficulties in physical or cognitive functioning were provided with home-based clinical oral examinations in Health 2000 Survey in which measurement for caries and periodontitis were not included. This might be the biggest weakness of the study in terms of representativeness of the population, as the people who experienced extreme difficulties in functional abilities and needed major support for daily functioning may remain excluded in this study. This might also be the reason for no significant associations between functional capacity and oral health using ADL and decayed teeth and teeth with deepened periodontal pockets ≥4mm. Most of them who participated in the clinical oral examination had no difficulty or minor difficulty in everyday functioning (ADL). As the majority of the sample had no or minor difficulty and only smaller numbers had major difficulty or were unable to perform some of the tasks, therefore, this might have resulted in no association between ADL and oral health. This study was unable to adjust for Mini Mental state examination

score (MMSE) due to large missing values in the data and hence, this might have produced confounding effects. Also, this study analyzed the association between exposure and outcome at only two points of time, therefore, further studies are required in which participants are followed up after every few years to determine changes in functional capacity as well as its effect on oral health.

6.4 Importance of the study

To the best of our knowledge, to date, this is the first longitudinal study that assessed functional ability and its association with oral health among the Finnish adult population. Additionally, the study analyzed each activity of ADL and IADL scale separately with aspects of oral health, which presents the idea that all of these activities are important in analyzing functional status of an individual and should be used as a set of activities rather than individually to identify people who need help and will in future be at-risk of poor oral health. This study also showed that IADL is an important indicator of functional capacity, as the process of functional disability starts with difficulties in IADL which makes it difficult to access health care services and increases the risk of poor oral health. This study also shows that periodontitis is a good indicator for poor oral health among the Finnish adult population because this is the most prevalent dental health problem among the Finnish population.

6.5 Implications for clinicians and policymakers

Dental practitioners are often more concerned about chronic diseases and the use of medications while undergoing a patient's history and often overlook the physical functional ability of an individual. This study has highlighted the importance of considering the functional ability of an individual as it can predict future oral health problems. As the literature supports the evidence that functional disability increases with increasing age thus, it is extremely important to examine the functional capacity of an individual in old age to predict their future risk of poor oral health. Since, if they are unable to perform daily routine tasks, it might be possible that they may have some difficulty in performing oral hygiene procedures such as removing plaque which can lead to caries, gingivitis and ultimately periodontitis. The findings of this study, along with the evidence from previous studies urge policymakers to actively pay attention regarding oral health issues of people with functional limitations and, provide them enough assistance that may enhance their oral health and quality of life.

7 CONCLUSION

This study investigated the longitudinal association between functional capacity and oral health particularly the association of inability to perform ADL and IADL with the risk of decayed teeth and deepened periodontal pockets ≥4mm among adult Finnish population.

The study found a significant association of functional ability with the risk of poor oral health among the Finnish adult population using IADL as an indicator of poor functional capacity. The present study concludes that IADL is an important indicator of functional capacity since functional disability starts with difficulties in IADL and can be detected at the start of aging. Besides, difficulties in ADL starts late in life after the appearance of difficulties in IADL and are, therefore, can be an important indicator of poor functional capacity in elderly people. Moreover, all activities in the ADL and IADL scale, that indicates the functional capacity of an individual is important and must be used as a set rather than individually to assess future risk of poor oral health. Furthermore, periodontitis is the most prevalent oral health problem among the Finnish population and thus, an important indicator of poor oral health among them.

8 RECOMMENDATION FOR FUTURE STUDIES

Based on the results of this study, it could be assumed that poor functional capacity (i.e. IADL) has an association with decayed teeth and teeth with deepened periodontal pockets ≥4mm and can be a predictor of poor oral health. However, due to the limitations of this study more longitudinal studies are needed on different populations with large sample sizes including homebound elderly people with limitations in the functional capacity to attain a more definitive conclusion about the association of functional capacity with oral health to prove causality. Further longitudinal studies can be performed using different measures of functional ability such as mobility and handgrip strength to determine the association of functional ability with caries and periodontitis and to assess the most appropriate and reliable method that can measure functional inability and its effects on oral health.

9 REFERENCES

Aas JA, Paster BJ, Stokes LN, Olsen I, Dewhirst FE. Defining The Normal Bacterial flora Of the Oral Cavity. Journal of Clinical Microbiology 2005; 43: 5721–5732

Abrass IB. The Biology and Physiology of Aging. Western Journal of Medicine 1990; 153:641-645

Afilalo J, Karunananthan S, Eisenberg MJ, Alexander KP, Bergman H. Role of Frailty in Patients with Cardiovascular Disease. The American Journal of Cardiology 2009; 103: 1616-1621

Ahlqvist A, Nyfors H, Suhonen R. Factors Associated with Older People's Independent Living from The Viewpoint of Health and Functional Capacity: A Register-Based Study. Nursing Open 2016; 3:79-89.

Al Jehani YA. Risk Factors of Periodontal Disease: Review of The Literature. International Journal of Dentistry 2014; 2014:9

Albandar JM, Kingman A. Gingival Recession, Gingival Bleeding, And Dental Calculus in Adults 30 Years of Age and Older in The United States, 1988-1994. Journal of Periodontology1999; 70:30-43.

Albandar JM. Global Risk Factors and Risk Indicators for Periodontal Diseases. Periodontology 2000 2002; 29:177-206.

Almerich-Silla JM, Almiñana-Pastor PJ, Boronat-Catalá M, Bellot-Arcís C, Montiel Company JM. Socioeconomic Factors and Severity of Periodontal Disease in Adults 35-44 Years. A Cross Sectional Study. Journal of Clinical and Experimental Dentistry 2017; 9: 988- 994.

Antunes JLF, De Andrade FB, Peres MA. How Functional Disability Relates to Dentition in Community-Dwelling Older Adults in Brazil. Oral Diseases 2017: 23:97-101.

Aromaa A, Heliövaara M, Impivaara O, Knekt P, Maatela J, Joukamaa M, Klaukka T, Lehtinen V, Melkas T, Mälkiä E, Nyman K. Health, functional limitations and need for care in Finland. Basic results from the Mini-Finland Health Survey. Publications of the Social Insurance Institution AL 1989; 32:793.

Aromaa A, Koskinen S. Health and Functional Capacity in Finland: Baseline Results of the Health 2000 Health Examination Survey. National Public Health Institute 2004 (Accessed 12.2.2018)

Avlund K, Holm-Pedersen P and Schroll M. Functional Ability and Oral Health among Older People: A Longitudinal Study from Age 75 To 80. Journal of American Geriatric Society 2001; 49:954–962.

Avlund K, Holm-Pedersen P, Morse DE, Viitanen M, Winblad B. Tooth Loss and Caries Prevalence in Very Old Swedish People: The Relationship to Cognitive Function and Functional Ability. Gerodontology 2004; 21:17-26.

Avlund K, Kreiner S, Schultz-Larsen K. Functional Ability Scales for the Elderly- A Validation Study. European Journal of Public Health 1996; 6: 35-42

Bauer, Janet G. The Index Of ADOH: Concept of Measuring Oral Self-Care Functioning in The Elderly. Special Care in Dentistry 2001;21: 63-67.

Bohannon RW. Hand-Grip Dynamometry Predicts Future Outcomes in Aging Adults. Journal of Geriatric Physical Therapy 2008; 31:3-10.

Boulding, K. On Possible Consequences of Increased Life Expectancy. Popular 2003.

Burgess RC. Dental Caries. Canadian Family Physician 1988; 34:1341.

Burt BA, Pai S. Sugar Consumption and Caries Risk: A Systematic Review. Journal of Dental Education. 2001; 65:1017-23.

Caufield PW, Li Y, Dasanayake A. Dental Caries: An Infectious and Transmissible Disease. Compendium of Continuing Education in Dentistry 2005; 26:10-6.

Chatterji S, Byles J, Cutler D, Seeman T, Verdes E. Health, Functioning, and Disability iIn Older Adults—Present Status and Future Implications. The Lancet 2015; 385:563-75.

Cognitive Function. Mosby's Medical Dictionary, 8th Edition 2009 (Accessed 5. 10. 2018)

Cognitive function. Neuronup 2018 (Accessed 5.10.2018).

Costa SM, Martins CC, Bonfim M De LC. A Systematic Review of Socioeconomic Indicators and Dental Caries in Adults. International Journal of Environmental Research and Public Health 2012; 9:3540-3574.

D'Orsi E, Xavier AJ, Steptoe A, Oliveira C, Ramos LR, Orrell M, Demakakos P, Marmot MG. Socioeconomic and Lifestyle Factors Related to Instrumental Activity of Daily Living Dynamics: Results from The English Longitudinal Study of Ageing. Journal of The American Geriatrics Society 2014; 62:1630-9.

D'aiuto F, Parkar M, Brett PM, Ready D, Tonetti MS. Gene Polymorphisms in Pro-Inflammatory Cytokines Are Associated with Systemic Inflammation in Patients with Severe Periodontal Infections. Cytokine 2004; 28:29-34.

Deas DE, Mackey SA, Mcdonnell HT. Systemic Disease and Periodontitis: Manifestations of Neutrophil Dysfunction. Periodontology 2000 2003; 32:82–104.

Deaths from Dementia and Alzheimer's Disease are Increasing. Statistics Finland 2017 (Updated: 29.12.2017)

Dementia. Fact Sheet. World Health Organization 2017 (Updated: September-2017)

Development Effort. Rev Epidemiology Santé Publique 1981; 29:413-419.

Dimitrova MM, Kukleva MP, Kondeva VK. Prevalence of Early Childhood Caries and Risk Factors in Children from 1 to 3 Years of Age in Plovdiv, Bulgaria. Folia Medica 2002; 44:60-3.

Ellefsen B, Holm-Pedersen P, Morse DE, Schroll M, Andersen BB, Waldemar G. Caries Prevalence in Older Persons with And Without Dementia. Journal of The American Geriatrics Society 2008; 56:59-67.

Esan TA, Olusile AO, Akeredolu PA, Esan AO. Socio-Demographic Factors and Edentulism: The Nigerian Experience. BMC Oral Health 2004; 4: 3.

Featherstone JD. Dental Caries: A Dynamic Disease Process. Australian Dental Journal 2008; 53:286-91.

Folstein MF, Folstein SE, Mchugh PR. Mini-Mental State: A Practical Method for Grading the Cognitive State of Patients for The Clinician. Journal of Psychiatric Research 1975; 12:189-98.

Fortin M, Bravo G, Hudon C, Lapointe L, Almirall J, Dubois MF. Relationship Between Multimorbidity And Health-Related Quality of Life of Patients in Primary Care. Quality of Life Research 2006; 15:83–91.

Fortin M, Bravo G, Hudon C, Vanasse A, Lapointe L. Prevalence of Multimorbidity Among Adults Seen in Family Practice. The Annals of Family Medicine 2005; 3:223-8.

Frencken JE, Sharma P, Stenhouse L, Gree D, Laverty D, Dietrich T. Global Epidemiology of Dental Caries and Severe Periodontitis–A Comprehensive Review. Journal of Clinical Periodontology 2017; 44:94-105.

Functional Assessment of the Elderly. Portal of Geriatric Online Education 2017. (Accessed 7-11-2017)

Functional Assessment of the Elderly. Project on Government Oversight (POGO) 2018 (Accessed 26.9.2018)

Gao XJ, Elliott JC, Anderson P. Scanning and Contact Micro Radiographic Study of the Effect of Degree of Saturation on the Rate of Enamel Demineralization. Journal of Dental Research 1991; 70:1332-7.

Genco RJ, Borgnakke WS. Risk Factors for Periodontal Disease. Periodontology 2000 2013; 62:59-94.

Ghezzi EM, Ship JA. Systemic Diseases and Their Treatments in The Elderly: Impact on Oral Health. Journal of Public Health Dentistry 2000; 60: 289-296.

Giampaoli S, Ferrucci LUIGI, Cecchi F, Lo Noce C, Poce A, Dima F, Menotti A. Hand-Grip Strength Predicts Incident Disability in Non-Disabled Older Men. Age and Ageing 1999;28: 283-288.

Gilbert G, Duncan R, Dolan T, Foerster U. Twenty–Four Month Incidence of Root Caries Among A Diverse Group of Adults. Caries Research 2001; 35: 366–75

Grace J, Amick MM. Cognitive Screening of Older Adults. Rhode Island Medical Journal 2005; 88:8.

Graf C. The Lawton Instrumental Activities of Daily Living Scale. The American Journal of Nursing 2008; 108:52-62.

Griffin SO, Regnier E, Griffin PM, Huntley V. Effectiveness of Fluoride in Preventing Caries in Adults. Journal of Dental Research 2007; 86: 410-5.

Growing older and staying well: Ageing and physical activity in everyday life. World Health Organization 1998 (Accessed 5.10.2018)

GU D, Gomez-Redondo R, Dupre M. E. Studying disability trends in aging populations. Journal of Cross-Cultural Gerontology 2015; 30: 21-49.

Hajishengallis G, Darveau RP, Curtis MA. The Keystone Pathogen Hypothesis. Nature Reviews Microbiology 2012;10: 717

Hajishengallis G. Complement and Periodontitis. Biochemical Pharmacology 2010; 80:1992-2001.

Hajishengallis G. Immunomicrobial Pathogenesis of Periodontitis: Keystones, Pathobionts, and Host Response. Trends in Immunology 2014; 35:3-11.

Hawkins RJ. Functional Status and Untreated Dental Caries Among Nursing Home Residents Aged 65 And Over. Special Care in Dentistry 1999; 19:158-163.

Hayasaki H, Saitoh I, Nakakura-Ohshima K, Hanasaki M, Nogami Y, Nakajima T, Inada E, Iwasaki T, Iwase Y, Sawami T, Kawasaki K. Tooth brushing for Oral Prophylaxis. Japanese Dental Science Review 2014; 50:69-77.

Heistaro S. Methodology Report-Health 2000 Survey. KTL-National Public Health Institute, Finland 2008 (Accessed 10.9.2017)

Holmén A, Strömberg E, Hagman-Gustafsson M.L, Wårdh I, Gabre, P. Oral Status in Home-Dwelling Elderly Dependent on Moderate or Substantial Supportive Care for Daily Living: Prevalence of Edentulous Subjects, Caries and Periodontal Disease. Gerodontology 2012; 29: 503–511.

Holt R, Roberts G, Scully C. Dental Damage, Sequelae, and Prevention. The Western Journal of Medicine. 2001; 174: 288.

Hu YN, Hu GC, Hsu CY, Hsieh SF, Li CC. Assessment of Individual Activities of Daily Living and Its Association with Self-Rated Health in Elderly People of Taiwan. International Journal of Gerontology. 2012; 6(2):117-21.

Hunter PB. Risk Factors in Dental Caries. International Dental Journal 1988; 38:211-7.

Innes EV. Handgrip Strength Testing: A Review of The Literature. Australian Occupational Therapy Journal 1999; 46:120-140.

Jefferson AL, Byerly LK, Vanderhill S, Lambe S, Wong S, Ozonoff A, Karlawish JH. Characterization of Activities of Daily Living in Individuals with Mild Cognitive Impairment. The American Journal of Geriatric Psychiatry 2008; 16:375-83.

Jette AM, Feldman HA, Douglass C. Oral Disease and Physical Disability in Community-Dwelling Older Persons. Journal of the American Geriatrics Society 1993; 41:1102-1108.

Kashket S, Van Houte J, Lopez LR, Stocks S. Lack of Correlation between Food Retention on the Human Dentition and Consumer Perception of Food Stickiness. Journal of Dental Research 1991; 70:1314-9.

Kassebaum NJ, Bernabé, E, Dahiya M, Bhandari B, Murray CJL, Marcenes W. Global Burden of Untreated Caries: A Systematic Review and Metaregression. Journal of Dental Research 2015; 94:650-658.

Kassebaum NJ, Smith AG, Bernabé E, Fleming TD, Reynolds AE, Vos T, Murray CJ, Marcenes W, GBD 2015 Oral Health Collaborators. Global, Regional, And National Prevalence, Incidence, And Disability-Adjusted Life Years for Oral Conditions For 195 Countries, 1990–2015: A Systematic Analysis for The Global Burden of Diseases, Injuries, And Risk Factors. Journal of Dental Research. 2017; 96:380-7.

Katz S, Downs TD, Cash HR, Grotz RC. Progress in Development of The Index Of ADL. Gerontologist 1970; 10:20-30.

Katz S, Ford AB, Moskowitz RW, Jackson BA, Jaffe MW. Studies of Illness in The Aged. The Index Of ADL: A Standardized Measure of Biological and Psychosocial Function. JAMA 1963; 185:914-919.

Kleinberg I. A Mixed-Bacteria Ecological Approach to Understanding the Role of The Oral Bacteria in Dental Caries Causation: An Alternative to Streptococcus Mutans and the Specific-Plaque Hypothesis. Critical Reviews in Oral Biology & Medicine. 2002; 13:108-25.

Knuuttila M, Suominen-Taipale L. Periodontal status. In book: Suominen-Taipale L,Nordblad A, Vehkalahti M, Aromaa A (eds). Oral health in the Finnish adult population, Health 2000 Survey. Helsinki: Publications of the National Public Health Institute B25/2008: 49–53.

Kornman KS, Crane A, Wang HY, Giovlne FS, Newman MG, Pirk FW, Wilson Jr TG, Higginbottom FL, Duff GW. The Interleukin-1 Genotype as A Severity Factor in Adult Periodontal Disease. Journal of Clinical Periodontology. 1997; 24:72-7.

Kossioni AE, Maggi S, Müller F, Petrovic M. Oral Health in Older People: Time for Action 2018; 9:3-4

Kowald A, Kirkwood TB. A Network Theory of Ageing: The Interactions of Defective Mitochondria, Aberrant Proteins, Free Radicals and Scavengers in The Ageing Process. Mutation Research/DNAging 1996; 316: 209-236

Lafortune G, Balestat G. Trends in Severe Disability among Elderly People. OECD 2007 (Accessed 1.2.2019)

Langlois JA, Keyl PM, Guralinik JM, Foley DJ, Marottoli RA, Wallace RB. Characteristics of Older Pedestrians Who Have Difficulty Crossing the Street. American Journal of Public Health 1997; 87:393-397

Lawton MP, Brody EM. Assessment of Older People: Self-Maintaining and Instrumental Activities of Daily Living. Gerontologist 1969; 9:179-186.

Lewis A, Wallace J, Deutsch A, King P. Improving the Oral Health of Frail and Functionally Dependent Elderly. Australian Dental Journal 2015; 60:95-105.

Li L, Chang HJ, Yeh HI, Hou CJ, Tsai CH, Tsai JP. Factors Associated with Leisure Participation Among the Elderly Living in Long-Term Care Facilities. International Journal of Gerontology. 2010; 4:69-74.

Listl S, Galloway J, Mossey PA, Marcenes W. Global Economic Impact of Dental Diseases. Journal of dental research 2015; 94:1355–1361.

Lundqvist A, Mäki-Opas T. Health 2011 Survey-Methods. National Institute for Health and Welfare, Finland 2016 (Accessed 10.9.2017)

Löe H, Anerud A, Boysen H, Morrison E. Natural History of Periodontal Disease in Man: Rapid, Moderate and No Loss of Attachment in Sri Lankan Laborers 14 To 46 Years of Age. Journal of Clinical Periodontology 1986; 13:431-440.

Mahlknecht P, Kiechl S, Bloem BR, Willeit J, Scherfler C, Gasperi A, Seppi K. Prevalence and Burden of Gait Disorders in Elderly Men and Women Aged 60–97 Years: A Population-Based Study. Plos One 2013; 8: 69627.

Marsh PD. Are Dental Diseases Examples of Ecological Catastrophes? Microbiology 2003; 149: 279-294.

Marsh PD. Microbiology of Dental Plaque Biofilms and Their Role in Oral Health and Caries. Dental Clinics 2010; 54:441-54.

Matthews DC, Clovis JB, Brillant MG, Filiaggi MJ, Mcnally ME, Kotzer RD, Lawrence HP. Oral Health Status of Long-Term Care Residents-A Vulnerable Population. Journal of the Canadian Dental Association 2012; 78:C3.

McWhinnie JR. Disability Assessment in Population Surveys: Results of the OECD Common Development Effort. Revue D'épidémiologie Et De Santé Publique 1981; 29:413-419.

Meyle J, Chapple I. Molecular Aspects of the Pathogenesis of Periodontitis. Periodontology 2000 2015; 69:7-17.

Mlinac ME, Feng MC. Assessment of Activities of Daily Living, Self-Care, and Independence. Archives of Clinical Neuropsychology 2016; 31:506-516.

Morishita M, Takaesu Y, Miyatake K, Shinsho F, Fujioka M. Oral Health Care of Homebound Elderly in Japan. Journal of Oral Rehabilitation 2001; 28: 717 - 20.

Müller F, Naharro M, Carlsson GE. What Is the Prevalence and Incidence of Tooth Loss in The Adult and Elderly Population in Europe. Clinical Oral Implants Research 2007; 18: 2–14.

Namal N, Can G, Vehid S, Koksal S, Kaypmaz A. Dental Health Status and Risk Factors for Dental Caries in Adults in Istanbul, Turke. La Revue De Santé De La Méditerranée Orientale 2008; 14:110–118

Newman MG, Carranza FA, Takei H, Klokkevold PR. Carranzas Clinical Periodontology. Elsevier Health Sciences 2006.

Nordenram G, Ljunggren G. Oral Status, Cognitive and Functional Capacity versus Oral Treatment Need in Nursing Home Residents: A Comparison between Assessments by Dental and Ward Staff. Oral Diseases 2002; 8:296-302.

Obeid P, Bercy P. Effects of Smoking on Periodontal Health: A Review. Advances in Therapy 2000; 17: 230-237.

Ono LM, Schneider IJ, Confortin SC, d'Orsi E. Paid Work and Physical Activity Preserve Functional Capacity in Elderly People: Epi Floripa Study. Gerontology and Geriatric Medicine 2015;1.

Oral Health. Fact Sheet. World Health Organization 2012 (Updated April 2012)

Paterson DH, Warburton DE. Physical Activity and Functional Limitations in Older Adults: A Systematic Review Related to Canada's Physical Activity Guidelines. The International Journal of Behavioral Nutrition and Physical Activity 2010; 7: 38

Patterson TL, Mausbach BT. Measurement of Functional Capacity: A New Approach to Understanding Functional Differences and Real-World Behavioral Adaptation in Those with Mental Illness. Annual Review of Clinical Psychology 2010; 6:139-154.

Peres KG, Cascaes AM, Leão ATT, Côrtes MIDS, Vettore MV. Sociodemographic and Clinical Aspects of Quality of Life Related to Oral Health in Adolescents. Revista De Saude Publica 2013; 47: 19-28.

Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C. The Global Burden of Oral Diseases and Risks to Oral Health. Bulletin of The World Health Organization 2005; 83: 661-669.

Petersen PE, Ogawa H. Strengthening the Prevention of Periodontal Disease: The WHO Approach. Journal of Periodontology 2005; 76:2187-2193.

Petersen PE, Yamamoto T. Improving the Oral Health of Older People: The Approach of the WHO Global Oral Health Programme. Community Dentistry and Oral Epidemiology 2005; 33:81-92.

Petersen PE. Sociobehavioural Risk Factors in Dental Caries–International Perspectives. Community Dentistry and Oral Epidemiology 2005; 33:274-9.

Petersen PE. The World Oral Health Report 2003: Continuous Improvement of Oral Health in the 21st Century – The Approach of The WHO Global Oral Health Programme. Community Dentistry and Oral Epidemiology 2003; 31:3–24.

Petersen PE. World Health Organization Global Policy for Improvement of Oral Health-World Health Assembly 2007. International Dental Journal 2008; 58:115-121.

Petersson LG. The Role of Fluoride in the Preventive Management of Dentin Hypersensitivity and Root Caries. Clinical Oral Investigations 2013; 17:63-71.

Philip P, Rogers C, Kruger E, Tennant M. Caries Experience of Institutionalized Elderly and Its Association with Dementia and Functional Status. International Journal of Dental Hygiene 2012; 10: 122-127.

Phillips EM, Davidoff DA. Normal and Successful Aging: What Happens to Function as We Age. Primary Psychiatry 2004; 11:35-40.

Pihlstrom BL, Michalowicz BS, Johnson NW. Periodontal Diseases. The Lancet 2005; 366:1809-20.

Radoï L, Luce D. A Review of Risk Factors for Oral Cavity Cancer: The Importance of a Standardized Case Definition. Community dentistry and oral epidemiology 2013; 41:97–109.

Rajab LD, Hamdan MA. Early Childhood Caries and Risk Factors in Jordan. Community Dental Health 2002; 19:224-9.

Razak PA, Richard KMJ, Thankachan RP, Hafiz KAA, Kumar KN, Sameer KM. Geriatric Oral Health: A Review Article. Journal of International Oral Health 2014; 6:110-116.

Reducing Risks, Promoting Health Life. The World Health Report 2002. World Health Organization WHO 2002.

Riebe D, Blissmer BJ, Greaney ML, Garber CE, Lees FD, Clark PG. The Relationship Between Obesity, Physical Activity, And Physical Function in Older Adults. Journal of Aging and Health 2009; 21:1159–1178

Roberts HC, Denison HJ, Martin HJ, Patel HP, Syddall H, Cooper C, & Sayer AA A Review of The Measurement of Grip Strength in Clinical and Epidemiological Studies: Towards A Standardised Approach. Age and Ageing 2011; 40:423-429.

Rockville, Maryland. Diagnostic Criteria and Procedures. Oral Health Surveys of The National Institute of Dental Research 1991.

Saarela RK, Soini H, Muurinen S, Suominen MH, Pitkälä KH. Oral Hygiene and Associated Factors Among Frail Older Assisted Living Residents. Special Care in Dentistry 2013; 33:56-61.

Saini R, Marawar PP, Shete S, Saini S. Periodontitis, A True Infection. Journal of Global Infectious Diseases 2009; 1:149-50.

Sanchez MA, Correa PC, Lourenço RA. Cross-Cultural Adaptation of The Functional Activities Questionnaire (FAQ) For Use in Brazil. Dementia & neuropsychologia 2011; 5:322–7.

Sánchez-García S, Reyes-Morales H, Juárez-Cedillo T, Espinel-Bermúdez C, Solórzano-Santos F, & García-Peña C. A Prediction Model for Root Caries in An Elderly Population. Community Dentistry and Oral Epidemiology 2011; 39:44-52.

Satariano WA, Ragheb NE, Branch LG, Swanson GM. Difficulties in Physical Functioning Reported by Middle-Aged and Elderly Women with Breast Cancer: As Case-Control Comparison. Journal of gerontology 1990; 45:3-11

Saunders RJ, Meyerowitz C. Dental Caries in Older Adults. Dental Clinics 2005; 49: 293–308.

Sebastiano, MD. Functional Capacity, Disability, And Status. Encyclopedia of Behavioral Medicine. Springer 2013 ;817-818.

Seitsamo J, Tuomi K, Martikainen R. Activity, Functional Capacity and Well-Being in Ageing Finnish Workers. Occupational Medicine 2006; 57:85-91.

Selwitz RH, Ismail AI, Pitts NB. Dental Caries. The Lancet 2007; 369:51-59.

Shulman KI, Herrmann N, Brodaty H, Chiu H, Lawlor B, Ritchie K, Scanlan JM. IPA Survey of Brief Cognitive Screening Instruments. International Psychogeriatrics 2006; 18:281-294.

Sikkes SA, De Lange-De Klerk ES, Pijnenburg YA, Scheltens P. A Systematic Review of Instrumental Activities of Daily Living Scales in Dementia: Room for Improvement. Journal of Neurology, Neurosurgery & Psychiatry. 2009 Jan 1;80(1):7-12.

Silness J & Löe H. Periodontal disease in pregnancy II. Correlation between oral hygiene and periodontal condition. Acta Odontologica Scandinavica 1964; 22(1): 121–135.

Slade GD, Spencer AJ. Periodontal Attachment Loss Among Adults Aged 60+ In South Australia. Community Dentistry and Oral Epidemiology 1995; 23: 237-242.

Slavkin HC, Baum BJ. Relationship of Dental and Oral Pathology to Systemic Illness. Jama 2000;284: 1215-1217.

Stabholz A, Soskolne WA, Shapira L. Genetic and Environmental Risk Factors for Chronic Periodontitis and Aggressive Periodontitis. Periodontology 2000 2010; 53:138-153.

Sudarsky L. Gait Disorders: Prevalence, Morbidity, and Etiology. Advances in Neurology 2001; 87:111–117

Sugars and Dental Caries. World Health Organization 2017. (Updated October 2017)

Sulander T, Heinonen H, Pajunen T, Karisto A, Pohjolainen P, Fogelholm M. Longitudinal Changes in Functional Capacity: Effects of Socio-Economic Position Among Ageing Adults. International Journal for Equity in Health 2012; 11:78.

Sulander T, Martelin T, Sainio P, Rahkonen O, Nissinen A, Uutela A. Trends and Educational Disparities in Functional Capacity Among People Aged 65–84 Years. International Journal of Epidemiology 2006; 35:1255-1261.

Sulander T. The Association of Functional Capacity with Health-Related Behavior Among Urban Home-Dwelling Older Adults. Archives of Gerontology and Geriatrics 2011; 52: 11-14.

Suominen AL, Varsio S, Helminen S, Nordblad A, Lahti S, Knuuttila M. Dental and Periodontal Health in Finnish Adults in 2000 and 2011. Acta Odontologica Scandinavica. 2018; 76:305-13.

Suominen-Taipale L, Nordblad A, Vehkalahti M, Aromaa A. Oral Health in The Finnish Adult Population: Health 2000 Survey. Kansanterveyslaitos 2008.

Supporting the Functional Capacity of Older People with Skill and Quality. SUFUCA 2017. (Accessed 25-9-2017)

Suzman R, Beard JR, Boerma T, Chatterji S. Health in An Ageing World-What Do We Know. The Lancet 2015; 385: 484-486

Tan HP, Lo EC, Dyson JE, Luo Y, Corbet EF. A Randomized Trial on Root Caries Prevention in Elders. Journal of Dental Research 2010; 89:1086-90.

Tervonen T, Knuuttila M, Nieminen P. Risk Factors Associated with Abundant Dental Caries and Periodontal Pocketing. Community Dentistry and Oral Epidemiology 1991; 19:82-87.

Thomson WM, Ma S. An Ageing Population Poses Dental Challenges. Singapore Dental Journal. 2014; 35:3-8.

Tiedemann A, Shimada H, Sherrington C, Murray S, Lord S. The Comparative Ability of Eight Functional Mobility Tests for Predicting Falls in Community-Dwelling Older People. Age and Ageing 2008; 37:430-435.

Tombaugh TN, Mcintyre NJ. The Mini-Mental State Examination: A Comprehensive Review. Journal of The American Geriatrics Society 1992; 40:922-35.

Tomey KM, Sowers MR. Assessment of Physical Functioning: A Conceptual Model Encompassing Environmental Factors and Individual Compensation Strategies. Physical Therapy 2009; 89:705-714.

Towards A Common Language for Functioning, Disability and Health ICF World Health Organization 2002 (Accessed 24-10-2017).

Tuna HD, Edeer AO, Malkoc M, Aksakoglu G. Effect of Age and Physical Activity Level on Functional Fitness in Older Adults. European review of aging and physical activity 2009; 6:99–106.

Usha C, Sathyanarayanan R. Dental Caries-A Complete Changeover (Part I). Journal of Conservative Dentistry 2009; 12:46.

Van Den Bussche H, Shon G, Kolonko T, Wegscheider K, Glaeske G, Koller D. Patterns of Ambulatory Medical Care Utilization in Elderly Patients with Special Reference to Chronic Diseases and Multimorbidity- Results from A Claims Data Based Observational Study in Germany. BMC Geriatrics 2011; 11:54.

Van Dyke, Thomas E, Dave S. Risk Factors for Periodontitis. Journal of The International Academy of Periodontology2005; 7:3.

Vehkalahti M, Varsio S, Hausen H. Hampaiden kunto. In: SuominenTaipale L, Nordblad A, Vehkalahti M, Aromaa A, eds. Suomalaisten aikuisten suunterveys. Terveys 2000 -tutkimus (in Finnish with English abstract). KTL, B16/2004, Helsinki 2004, pp. 73─97.

Wesnes KA, Harrison JE. The Evaluation of Cognitive Function in The Dementias: Methodological and Regulatory Considerations. Dialogues in Clinical Neuroscience. 2003; 5:77-88.

Winn D, Lee YC, Hashibe M, Boffetta P. The INHANCE Consortium: Toward A Better Understanding of The Causes and Mechanisms of Head and Neck Cancer. Oral diseases 2015; 21:685–693.

Woodford HJ, George J. Cognitive Assessment in the Elderly: A Review of Clinical Methods. QJM: An International Journal of Medicine 2007; 100:469-484.

World population ageing. United ageing. United Nations, Department of Economic and Social Affairs, Population Division. 2013 (Updated19.2.2013).

World Population Prospects. United Nations 2017 (Accessed 14-11-2017)

Wu B, Plassman BL, Crout RJ, Liang J. Cognitive Function and Oral Health among Community-Dwelling Older Adults. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 2008; 63:495-500.

Yadav K, Prakash S. Dental Caries: A Microbological Approach. Journal of Clinical Infectious Disease Practice 2017; 2:2.

Yu YH, Lai YL, Cheung WS, Kuo HK. Oral Health Status and Self-Reported Functional Dependence in Community-Dwelling Older Adults. Journal of The American Geriatrics Society 2011; 59:519-523.