View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Ghent University Academic Bibliography

DEALING WITH ORAL HEALTH INEQUALITIES IN FLANDERS, BELGIUM

Martijn Lambert

UNIVERSITEIT GENT

© Martijn Lambert, 2018

All rights reserved. No part of this publication may be translated, copied or reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without permission in writing from the author.

Promotor:	Prof. dr. Luc De Visschere (Ghent University)
Co-Promotor:	Prof. dr. Luc C. Martens (Ghent University)
Advisory committee:	em. Prof. dr. Jacques Vanobbergen (Ghent University)
Dean:	Prof. dr. Piet Hoebeke (Ghent University)
Rector:	Prof. dr. Rik Vandewalle (Ghent University)

UNIVERSITEIT GENT

DEALING WITH

ORAL HEALTH INEQUALITIES

IN FLANDERS, BELGIUM

Martijn Lambert

2018-06-28

Department of Community Dentistry and Oral Public Health

Faculty of Medicine and Health Sciences

Ghent University

FACULTY OF MEDICINE AND HEALTH SCIENCES

EXAMINATION COMMITTEE

Prof. dr. Koen Van Herck (Ghent University, Belgium) - Chair

Prof. dr. Peter Bottenberg (Ghent University, Free University Brussels, Belgium)

Prof. dr. Mieke De Bruyne (Ghent University, Belgium)

Prof. dr. Stéphanie De Maesschalck (Ghent University, Belgium)

Dr. Georgios Tsakos (University College London, United Kingdom)

Prof. dr. Linda Van Den Berghe (Ghent University, Belgium)

All men are created equal.
Some, it appears, are created a little more equal than others…

(Ambrose Bierce)

CONTENTS

LIST OF ABBREVIATIONS

ANOVA:	Analysis of Variance
CHW:	Community Health Worker
CI:	Care Index / Confidence Interval
COHW:	Community Oral Health Worker
CRFA:	Common Risk Factor Approach
DMFT/dmft:	The number of Decayed, Missing and Filled Teeth
DMFS/dmfs:	The number of Decayed, Missing and Filled tooth Surfaces
DPSI:	Dutch Periodontal Screening Index
ECC:	Early Childhood Caries
e.g.:	example given
fig:	figure
ICDAS:	International Caries Detection and Assessment System
IMA:	Inter-mutualistic Agency
n:	number
NIHDI:	National Institute for Health and Disability Insurance
OECD:	Organisation for Economic Cooperation and Development
OHDRES:	Oral Health Data Registration and Evaluation System
OHRQoL:	Oral Health-related Quality of Life
p:	an estimate of the probability that the study results could have occurred by chance
PUFA:	the sum of the teeth with pulp exposure (P), ulcerations (U), fistulas (F) and abscesses, due to caries
Q:	Quartile
RCT:	Randomised Controlled Trial
RI:	Restorative Index
SD:	Standard Deviation
SE:	Standard Error
SEP:	Socio-economic Position
SES:	Socio-economic Status
TI:	Treatment Index
WHO:	World Health Organisation

LIST OF FREQUENTLY USED TERMS

DMFT/dmft

Index corresponding to the 'caries experience' an individual had during his life, counting the number of decayed (**D**), missing (**M**) and filled (**F**) teeth, due to dental caries. Capital letters are used to describe permanent dentition, whether minuscule letters are used for deciduous teeth. The D-component can contain several sublevels, based on the International Caries Detection and Assessment System (ICDAS). This system makes use of six subcategories of caries, going from the first visible change in enamel (score 1) to extensive cavities with visible dentin possibly reaching the pulp (score 6). The most common subscales for the D-component used in scientific paper are caries lesions at D_1 level (early enamel lesions, the so-called 'white spots') and D_3 level (visible decay into dentine). In these cases, one will mention D_1MFT and D_3MFT respectively.

Based on the DMFT-score, three derived indices can be calculated to assess the proportion of caries lesions being treated, all ranging from 0 to 100%:

Care Index: CI= (FT/(D+M+FT))*100

Restorative Index: RI= (FT/(D+FT)) *100

Treatment Index: TI= ((M+FT)/(D+M+FT))*100

The added value of three indices instead of one single index is based on subtle nuances in their interpretation. Restorative Index does not consider the missing teeth, because there can be doubts whether teeth were removed due to caries or due to other factors (trauma, periodontal infection, orthodontic treatment). Care Index partially involves the missing teeth, but the index does not consider a tooth extraction as a 'solution', but as part of the problem. Individuals are literally 'missing' a tooth, considering tooth extractions as a 'lost chance'. On the other hand, Treatment Index proposes tooth extraction as part of the solution, because it removes a (potential) focus of infection. It gives the same value to fillings and extractions. None of these indices can be considered as 'all-embracing', so it is good to compare them. When two subgroups differ significantly in restorative index, but not in treatment index, this means that one of the groups received more tooth extractions, which can be relevant to explore the severity of the dental decay and the way of treating it.

Increased Allowance

In Belgium, there is a compulsory health care insurance, which covers the costs of many oral health care services for 75-80%. However, Belgian residents can be entitled to an increased allowance for health care interventions when the annual family income is lower than €18,730.66, increased by €3,467.55 for every additional family member (limit calculated for 2017). In this case, basic dental care is covered for 100%, provided that the dentist did not count supplements and acceded to the convention between the national health insurance agency and dental professional organisations. The

increased allowance is not always automatically attributed. Often, the concerned person should apply for it.

Maximum Bill

In case of excessive medical costs, the Belgian government introduced a mechanism, known as the "Maximum Bill". This system calculates for every individual a cost limit for medical care which is covered by the obligatory health insurance. When medical costs exceed this limit, they will be entirely and automatically reimbursed without applying for it. The cost limit is not a fixed threshold, but fluctuates according to the family income. The lower the family income, the lower the cost limit and the sooner additional medical costs will be reimbursed.

Third-party payment

In Belgium, most patients pay the dentist after dental treatment, and will be reimbursed for the largest part of the dental fee via the health insurance agency. However, special subgroups, such as minors and individuals being entitled to an increased allowance, can ask not to advance the entire dental fee, but to pay only the part which is not reimbursed by the insurance. In this third-party payment, the dentist receives the reimbursed part of the dental fee directly from the health insurance agency. However, the dentist is not obliged to apply the third-party payment.

INTRODUCTION

1. (Oral) Health inequalities: definitions and patterns

1.1 Health inequalities in general

Highly educated and wealthy individuals live longer and are healthier than underprivileged people (WHO, 2008). This suggests that health must be influenced by social factors. Health inequalities can be considered as **differences in health among populations in society, which are avoidable and unfair**. These differences in health are related to the general conditions in which people are born and live, called **social determinants**. According to Solar and Irwin (2010), health inequalities are determined by patterns of social stratification arising from the systematic '*unequal distribution of power, prestige and resources among groups in society*'. The unequal access to these intermediary factors is related to differences in exposure and vulnerability to health-compromising conditions, which can lead to a vicious circle. This mechanism is a fundamental principle through which socio-economic position generates health inequalities.

Health inequalities do not dichotomously divide populations into 'wealthy healthy individuals' and 'poor unhealthy individuals', with a distinct border one should avoid to cross. No, health inequalities appear in a **gradient**. There is a consistent stepwise relationship across the whole social spectrum, with health being worse at each point when descending along the social ladder. Figure 0.1, by example, shows the inverse correlation between life expectancy of 25-year old men and their educational level (Van Oyen *et al.*, 2011).

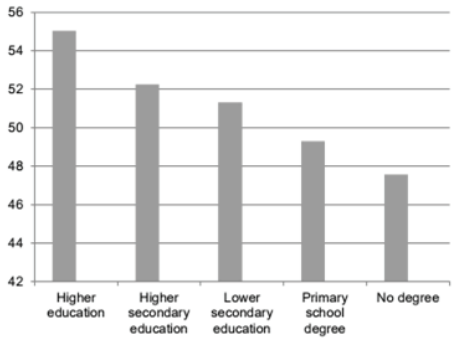

Fig 0.1: Life expectancy of 25 year old men (y-axis), according to educational level (x-axis) (Source: Van Oyen et al, 2011)

This means that health risks do not have an on/off-switch, but appear in a continuum, with the most underprivileged groups having the highest risk, and the most wealthy groups the lowest. However, this risk is never reduced to zero.

1.2 Oral health inequalities

1.2.1 Inequalities in oral health condition

Deprived oral health is a major public health problem affecting 3.9 billion people worldwide, and untreated caries in permanent teeth was globally the most prevalent disease in 2010, according to Marcenes *et al.* (2013) and Kassebaum *et al.* (2015). In the same ranking, severe periodontitis reached the sixth place and untreated decay in deciduous teeth was ranked at place ten. Despite their widespread appearance, various national and international reports show that the prevalence of oral health problems, such as **caries**, **periodontal diseases, edentulousness** and **erosive tooth wear**, is not equally distributed. (Sanders *et al.,* 2006; Sabbah *et al.*, 2007; Vanobbergen *et al.*, 2010; Petersen & Kwan, 2011; Tsakos *et* al., 2011; Costa *et al.*, 2012; Do, 2012; Ravaghi *et al.*, 2013, Carvalho *et al*., 2014). The global impact of these inequalities was clearly demonstrated by Schwendicke *et al.* (2015). They performed a systematic review of 155 studies, describing social inequalities in caries experience in highly-developed countries, developing countries and underdeveloped countries. The association between low socio-economic status and dental caries seems to be even stronger in high-income countries.

Oral and oropharyngeal cancers are the seventh most commonly occurring cancer and the ninth in terms of mortality, according to the World Cancer Report (Stewart & Wild, 2014). In 2012, there were 442,760 new oral cancer diagnoses, and 241,418 deaths reported worldwide (Ferlay *et al.*, 2015). According to a large pooled data analysis, head and neck cancers were associated with lower educational status and lower income, controlled for behavioural risk factors as alcohol use and smoking (Conway *et al.,* 2015). Although survival rates are improving in recent years for oropharyngeal and oral cavity cancer, the socio-economic gap in survival between wealthy and deprived neighbourhoods seems to widen, in particular among men (Molina *et al.*, 2008; Kwok *et al.*, 2010; Auluck *et al*, 2016).

Regarding **dentofacial anomalies**, there is only moderate evidence to associate socio-economic status with delayed tooth eruption (Almonaitiene *et al.*, 2010). Celeste & Nadanovsky (2010) could not demonstrate an association between malocclusion and income inequalities. Regarding **orthodontic treatment**, inequalities are more prominent. More affluent patients in Scotland and Northern Ireland were significantly more likely to receive orthodontic treatment, compared to individuals of lower social class (Telford *et al.*, 2012; Ulhaq *et al.*, 2012). Although the authors could not reveal the causes of these inequalities, there might be a link with access to orthodontic care, which is mostly expensive.

1.2.2 Inequalities in oral health behaviour

Besides oral health outcomes, there is also a clear socio-economic gradient in **oral health behaviour**. People with lower educational level report a higher prevalence of health-compromising behaviours (Singh *et al.*, 2013). Sabbah *et al.* (2009) revealed socio-economic disparities in **smoking behaviour**, **dental attendance**, **frequency of consuming fresh fruits and vegetables** and extent of dental calculus, which was used as a marker for **oral hygiene**. Regarding differences in beverage intake,

preschool children of lower SES families drink **more sugared beverages and less water** than their high SES peers (Pinket *et al.*, 2016). According to Zarnowiecki *et al.* (2014), maternal education was identified as the most consistent predictor of children's diet and thus linked to overweight.

A very interesting component of the survey of Sabbah *et al.* (2009) was that socio-economic disparities could not be eliminated after adjusting for health behaviours in the statistical analyses. This suggests that oral health inequalities cannot be linked exclusively to compromising behaviour of the underprivileged groups.

Dental treatments have specific characteristics which can reinforce existing health inequalities. They are mostly highly technical, requiring expensive equipment and materials, leading to high treatment costs. Additionally, they face the stigma of being painful. A systematic review by Wide Boman *et al.* (2013) estimated that up to 5% of the global population are affected by dental fear and phobia. These individuals are not only challenged by dental avoidance and worsened oral health outcomes, but there also seems to be a link between dental phobia and social and psychological problems. According to international literature, there is a significant association between educational level and **dental anxiety** (Acharya, 2008; Egbor & Akpata, 2014).

1.2.3 Inequalities in dental care provision

Two Swedish surveys revealed that socio-economic factors were strongly associated with reported oral health care utilisation (Berglund *et al.*, 2017; Hakeberg & Wide Boman, 2017). In a multivariate model, lack of emotional or instrumental social support was associated with an odds ratio of 1.23 (95%CI=[1.18-1.34]) and 1.89 (95%CI=[1.67-3.13]) respectively to refrain from seeking dental care. Having financial problems corresponded to an adjusted OR of 3.57 (95%CI=[3.19-4.00]).

To cope with the oral health care demand and its inherent costs, insurance agencies were founded. This insurance provision can be a tool to tackle inequalities, since Manning already noticed in 1985 that oral health care demand was positively correlated to insurance coverage, a finding which was confirmed by later authors (Manski & Cooper, 2007; Davis *et al.*, 2010). There is also evidence to suggest that health inequalities might be influenced by certain features of health care systems, including level of expenditure, coverage, public/private care ratio, accessibility and extent of intersectoral policies (Mackenbach, 2003; Quinonez & Figueiredo, 2010).

Where care is mostly private, it can be too expensive for some subgroups in society, such as ill and poor people (Leake & Birch, 2008). The USA are one of the best examples to demonstrate the impact of oral health care coverage on health care consumption and health outcomes. In 1965, the US government introduced the 'Medicaid' program, which payed for medical assistance for low-income families, including dental coverage. However, in July 2009, California Medicaid eliminated its comprehensive adult dental coverage, due to lack of budget. Singhal *et al.* (2015) disclosed the devastating consequences of this policy measure. Eliminating Medicaid adult dental coverage resulted in an immediate increase in the use of dental emergency visits, raising to more than 1,800 additional visits per year, especially affecting younger adults and ethnic minorities. Additionally, the higher amount of emergency treatments led to increased health costs.

Also in Europe, the role of dental coverage should not be underestimated. Palencia *et al.* (2014) investigated the impact of oral care services on socio-economic inequalities within adults older than 50 out of 11 European countries. The authors revealed that socio-economic inequalities in oral health care consumption were more prominent in countries without public dental care coverage, compared to countries with a certain public oral health care system.

Grytten (2016) provided a comprehensive overview of the different provider payment systems in oral healthcare. The **fee-for-service** system is the most common-used in dentistry, also in Belgium. Further, **capitation system** and a **salary payment** can be found. More recent, a new term has been introduced, the so-called **"pay-for-performance"**. Table 0.1 defines these four systems and summarises their main advantages and shortcomings.

Fee-for-service: the care provider is paid per service, the income is directly linked to the level of activity
+ suitable for services which are easy to measure
+ highly qualitative care
- can divert the dentists' attention away from services which are important, but difficult to measure (e.g. communication with vulnerable patients, preventive advise)
- supplier induced demand: the care provider is paid per service, so can be encouraged to treat more than necessary
Pay-per-performance: provider reimbursements directly linked to certain health gains
+ focus on health gain
- difficult to identify indicators that lead to improvements in health
- lack of provider acceptance
- lack of clinical markers to determine the severity of oral diseases and possible health gains
Per capita payment: dentist gets paid for each person he or she has responsibility for providing dental services to
+ focus on preventing disease
- risk of undertreatment, since more treatment is not related to more income
- risk of patient selection, with focus on the most healthy patients
Fixed salary
+ dentist can spend additional time on patients with special needs
- risk of productivity loss and undertreatment

Table 0.1: different provider payment systems and their main advantages and shortcomings

Table 0.1 shows that every payment system has its positive aspects and possible risks, leading to the conclusion that there might be no single ideal system for oral healthcare, which was confirmed by a Cochrane review (Brocklehurst *et al.*, 2013).

According to Grytten (2016), both dentists and society can benefit from a mixed payment model, seeking the right balance between a fee-for-service system and payment per capita. He pleads for offering the dentist a flexible contract with a fixed salary component as one of the components. However, this requires a healthcare system with a strong third-party payer.

The above section suggests that the characteristics of a certain country, including its oral healthcare organisation and provider payment system, play an important role in oral health outcomes. However, it should be clear that the demand for oral healthcare does not only depends on the

effective costs of oral health services but also on personal preferences and the available resources (Listl *et al*., 2014[a]).

A next aspect in inequalities in oral health care provision is linked to **barriers experienced by dental professionals** towards providing care to socially deprived patient groups. According to Bedos *et al.* (2014), possible frustrations expressed by dentists are missed appointments, difficulties in performing non-covered treatments and low government fees. According to the dental professionals in this survey, it was the government's duty to resolve the experienced financial shortcomings.

Remarkable findings on inequalities in care provision were found by Bisgaier *et al*. (2011). The authors experimented with "mystery calls" in a random sample of 85 dental clinics, of which 41 were enrolled in the Medicaid care program for low-income residents. Each clinic received two phone calls with an interval of 4 weeks. The caller pretended to be a mother of a 10-year old boy with a symptomatic fractured permanent front tooth. The only difference between the two calls was the child's insurance coverage (public coverage by Medicaid versus private Blue Cross dental coverage). From Medicaid beneficiaries, only 36.5% got a dental appointment, compared with 95.4% of Blue Cross-insured children with the same treatment need. Even among dental practitioners who were officially enrolled in the Medicaid program, Medicaid children were still 18.2 times less likely (95%CI=[3.1- ∞]) to get an appointment, compared to those who were privately insured.

Reluctance to treat underprivileged patient groups might have its onset even before actually working on the field. Major *et al*. (2016) conducted a longitudinal survey on dental students' (n=132) attitudes towards treating underserved populations over four years of education. The results were quite remarkable: Although students' willingness to treat medically complex populations (e.g. drug users, HIV/AIDS patients) became more positive due to increased knowledge, they were less willing to treat low-income patients, frail elderly, homebound, and non-English-speaking populations after graduation. Furthermore, progressing through dental school, there was decreasing agreement that it is the responsibility of the dentist to treat underprivileged populations.

Not only receiving dental care in general depends on social class, but also the type of treatment differs between low- and high-income individuals. In a sample of 11-12 year old children, Telford *et al*. (2012) showed that orthodontic treatment was more concentrated in higher socio-economic groups, whether extractions and restorative treatments, including endodontic treatments, were more prevalent in underprivileged groups.

1.2.4 The impact of oral health inequalities

Oral health inequalities are more than just *differences in oral health*. Within this chapter, the author wants to emphasise that the oral health inequality issue goes widely beyond the oral cavity of a single individual. Oral health inequalities affect people's general health, wellbeing and appearance, and have a substantial impact on health care budgets.

A higher degree of oral infection will lead to more tooth loss with a direct negative impact on functionality and quality of life. According to Cohen-Carneiro *et al.* (2011), **oral health-related quality of life (OHRQoL)** was inversely associated with low educational level, low income, and belonging to

ethnic minorities. Further, poor self-perception of oral health showed to be also associated with unfavourable social, demographic, economic and psychosocial factors, as well as with compromising habits and poor clinical oral conditions (Gabardo *et al.*, 2013).

Oral health is linked to **general health** via various pathways. There is a mutual interaction between periodontal health and glycaemic control in people with **diabetes** (type II). Poorly controlled diabetes is associated with candidiasis, periodontitis, saliva gland dysfunction and compromised healing after tooth extraction. There is strong evidence to assume that periodontal treatment leads to a significant and clinically relevant reduction in HbA1c and in the risk of major diabetic complications (Simpson *et al.*, 2010; Sgolastra *et al.*, 2013). Further, the prevalence and incidence of **coronary heart disease** are both increased in people with periodontal disease (Bahekar *et al.,* 2007; Humphrey *et al.*, 2008). There also seems to be an association between periodontal bacteria and mortality risk from **aspiration pneumonia** in the elderly (Awano *et al.*, 2008; Pace & McCullough, 2010). Periodontitis during pregnancy is associated with greater risk of having a **preterm birth** or a child with **lower birth weight**, although the independent impact of periodontal disease in this matter still needs further investigation (Konopka & Paradowska-Stolarz, 2012). Radnai *et al.* (2009) found that periodontal treatment completed before the 35th week of pregnancy seemed to have a beneficial effect on birth weight and time of delivery. Reciprocally, having a very low birth weight was determined as a significant risk factor for having enamel defects in the permanent incisors and first molars (Nelson *et al.,* 2010). Regarding caries, there is a significant relationship between childhood obesity and dental decay (Hayden *et al.*, 2012).

Deficient oral health can be a **social handicap**. Compromised physical attractiveness may affect people's subjective well-being by compromising the chances to find a job or a partner (Hamermesh & Biddle, 1994). There is a limited amount of evidence to assume that dental treatment can improve employment outcomes, but more well-conducted studies are needed in this respect (Singhal *et al.*, 2013).

It is important to highlight the **inter-generational impact** of oral health inequalities. Children's oral health is largely affected by family-related factors. Poverty can affect oral health due to malnutrition or lack of healthy food, since sugary snacks are mostly less expensive than a well-balanced diet (da Fonseca, 2012). Further, key oral health behaviours are acquired at home during childhood and should lead children to carry out good preventive oral health. Recent systematic reviews summarized studies on the impact of parental factors and family relationships on childhood dental caries (Hooley *et al.*, 2012; Duijster *et al.,* 2013 Kumar *et al.*, 2016). Children of highly educated and high income parents had lower risk of dental caries. Another systematic review confirmed the relationship between family environment, parental oral health behaviour and beliefs and children's adherence to regular dental care (Badri *et al.*, 2014). There is even some evidence to state that mothers are a primary source of transferring Mutans Streptococcus, the main bacteria in the dental decay process, to their children (Douglass & Tinanoff, 2008).

Parental socio-economic status also has a clear impact on children's oral health-related quality of life (OHRQoL). Again, children from high income families and parents with higher educational attainment had better OHRQoL (Kumar *et al.*, 2014). Also mothers' age, family structure, household crowding and presence of siblings were significantly associated with children's OHRQoL.

Children with poor oral health are at greater risk to miss days from school because of dental pain, with a factor of almost 3, resulting in **poorer school performance**, which can be the start of a vicious circle (Jackson *et al.,* 2011; Piovesan *et al.,* 2012). Patterns of social inequalities in childhood are an early marker of future oral health inequalities. Two life-course studies showed that children's low socio-economic status (SES) contributed to higher levels of tooth decay and periodontal disease in adult life, after adjusting for adult SES (Poulton *et al.*, 2002; Thomson *et al.*, 2004). These findings are confirmed by more recent evidence. Peres *et al.* (2011) stated that cumulative poverty from birth to the age of 24 was linked to more unhealthy teeth, whereas Listl *et al.* (2014[b]) described the enduring impact of childhood financial hardship on oral health in later life. A systematic review by Schuch *et al.* (2017) demonstrated the potential longitudinal impact of low SES on poorer periodontal health later in life.

Inequalities are present in every aspect of today's society, and it is very hard to reduce them. The persistence of social inequalities disfavours subgroups at the lower end of the social scale, but might offer lucrative opportunities for others, who may have more influence. Underprivileged subgroups do not only have less resources, but are also less present in politics and decision making to change their situation. Furthermore, the return on investment of reducing inequalities will not be on short term, which might make it less politically attractive.

However, it is important to emphasise the expected benefits for society, when inequalities are reduced. In the European Union, costs related to health inequalities amount to 15% of social security systems costs and to 20% of the health care system's budget (Mackenbach *et al.*, 2011). According to calculations made by the International Centre for Oral Health Inequalities Research and Policy (ICOHIRP), global productivity loss due to oral diseases in 2010 was estimated at 138 billion US dollars (Watt *et al.*, 2015).

2. Social determinants

In the previous section, oral health inequalities were defined as "*differences in oral health among populations in society, which are avoidable and unfair*". In this respect, it is necessary to clearly describe which subpopulations are compared. Mostly, terms as "**deprivation**", "**underprivileged groups**" and "**lower socio-economic status/position (SES/SEP)**" are used in function of income and financial resources. Although, emphasis should not be put exclusively on the level of material deprivation. When underprivileged groups are mentioned in this paper, it comprises the broader image of education, employment and social background, including ethnicity.

To measure the **level of deprivation**, international literature provides various tools. Especially in the United Kingdom, several measuring instruments were developed. However, some of these indices are area-specific, giving a certain deprivation score to a demarcated region or district. This specificity makes them hard to use in other areas. Area-based indicators can be very useful in large nationwide surveys and ecological studies, comparing regions or quarters with a different level of prosperity. However, providing a general score to an area overlooks individual differences within this area, which makes these indicators less useful to examine social differences at individual level.

2.1 Indicators at a geographical level

The **Gini coefficient**, developed by Corrado Gini in 1936, is the most used international criterion to measure inequalities in income distribution. Its value varies between 0 and 1, with 0 corresponding to perfect equity (everyone has the same income). On the other extreme end, a Gini ratio of 1 expresses maximal inequality, which means that in a certain sample, one individual has all the income. According to the latest global data from the Organisation for Economic Cooperation and Development (OECD[a], 2017), Costa Rica had the highest Gini index (0.49) and Iceland the lowest (0.25). Great-Britain (0.36) and the USA (0.39) also showed relatively high income disparities. For Belgium, OECD reported a Gini coefficient of 0.27 for 2014. This is one of the lowest ratios in the European Union. Only Slovak Republic, Slovenia (both 0.25), Denmark, Czech Republic and Finland (0.26) reported less income inequalities.

The **Underprivileged Area Score (Jarman-8-UPA score; Jarman, 1990)** was created to identify underprivileged areas in the UK, by questioning general practitioners on their perceptions of workload and patient needs. The survey revealed eight social determinants which increased the workload of general practitioners (table 0.2). Mostly, a composite score is used, combining different determinants into one score to measure the deprivation level of areas, families or individuals.

The **Townsend index** and **Carstairs & Morris index** are other examples of international composite deprivation indices, both summarized in table 0.2 (Townsend *et al.*, 1988; Carstairs & Morris, 1991).

The European Union investigates the level of deprivation of its member states by means of a standardised annual survey, the "**European Union Statistics on Income and Living Conditions (EU-SILC)**". On a micro-level, the city of Ghent (Belgium) developed an index to explore the level of deprivation for each quarter, the so-called "**Deprivation atlas**", which was edited in 1999 and 2002, and is updated on a regular base**.** The atlas combines statistics per quarter on demography, education, housing and socio-economic situation.

Deprivation atlas (2002)	Jarman score (1991)	Carstairs and Morris (1991)	Child & Family (2010)	Townsend Index (1988)
Unemployment	Unemployment	Male unemployment	Professional status	Unemployment
% entitled to social housing	Household overcrowding	Household overcrowding	Housing	Household overcrowding
Family income	Frail elderly	Non-car ownership	Family income	Non-car ownership
% ethno-cultural minorities	Ethnic minorities	Low social class	Maturation of the child(ren)	Non-home ownership
% entitled to public support	No education		Educational level	
	Children <5y old		Health	
	Single parents			
	Frequent relocating			

Table 0.2: different composite deprivation indices and their criteria.

2.2 Indicators at an individual level

'Child & Family' (Kind & Gezin), a Flemish organisation providing primary health care to new-born children until the age of three, determined six criteria to measure deprivation. These criteria are:

- Family income: there is no fixed monthly income or the family income (decreased with existing debts) is lower than the national living wage. In Belgium, this is €1.190,27/month for a family with at least one unmarried child, according to the latest figures from 2017-09-01 (http://www.mi-is.be/nl/equivalent-leefloon).
- Educational level of the parents: at least one of the parents has no diploma of higher secondary school, exclusively attended schools for special educational needs, or is illiterate.
- Maturation of the children: no or irregular attendance of nursery education, parents experience difficulties in the care of their children
- Professional status of the parents: precarious employment (e.g. temporary contracts), sheltered work, or both parents are unemployed
- Housing: dilapidated, unhealthy and/or unsafe housing, no or deficient utilities
- Health: poor health status of the family members, low health literacy and participation, chronic illness, handicaps.

Employment has a prominent position in all indices. According to OECD[a] (2017), employment rates are defined as the ratio of the employed to the working age population. For the first quarter of 2017, Belgium had an employment rate of 62.4%. This is lower than the mean score for the European Union (67.2%) and the global OECD average (67.4%). OECD also provides data on the number of unemployed people, reported as a percentage of the labour force (OECD[c], 2017). In this figures, unemployed individuals are those who reported to be without work, to be available for work and to have undertaken steps to find a job in the last four weeks. For the first quartile of 2017, Belgian

unemployment rate was 7.6%, which was lower than the European average (7.9%), but higher than the global mean score of 6.0%. The perceived contradiction between the Belgian employment rate of 62.4% and the rather 'good' unemployment rate of 7.6% might be partially explained by the proportion of chronically ill adults, who are not working but neither considered as unemployed.

Both Deprivation Atlas and Jarman score mentioned '**ethnicity**' as one determinant to indicate underprivileged groups. In literature, migrant children show to have worse health outcomes compared to native residents (Riggs *et al.*, 2014). Racial disparities in health can be partially explained by **health literacy**, which can be defined as 'an individual's ability to gain access to, understand and use health information for promoting and maintaining health' (WHO, 2009). Health literacy is not just the ability to read pamphlets or food labels, or to make an appointment. It refers also to personal skills and confidence to take actions to improve health, not only at personal level but also at community level.

A systematic review confirmed the link between race and health literacy, and further demonstrated the association of low health literacy with more hospitalisations, more frequent use of emergency care, lower receipt of mammography screening and influenza vaccination, poorer ability to take medications appropriately and to interpret labels and health messages (Berkman *et al.*, 2011). In contrast, **acculturation**, which is the level of cultural adaptation from migrant groups to the culture of the country they live in, is positively associated with better oral health and a higher use of oral health care services (Gao & McGrath, 2011).

Ethnic minority groups include all immigrants and their descendants, including political and economic refugees and asylum seekers. Children from refugee backgrounds have a higher risk to show poor oral health, with the corresponding adverse effects on their general health and well-being (Riggs *et al.*, 2017). The undocumented, "illegal" immigrants are a very vulnerable subgroup, consisting of a considerable number of people, trying to remain undiscovered by local authorities. In contrast to asylum seekers and recognised refugees, they do not have a residence permit and are considered to stay illegally in the country. Their estimated number varies between 7 and 13% of the total number of residents with a foreign nationality, but with an official residence permit (Triandafyllidou, 2009). In Belgium, there were 1,295,660 non-Belgian legal foreigners on the 1st of January 2016, which means that the number of undocumented immigrants must lie between 85,000 and 160,000, corresponding to approximately 1% of the total Belgian population (Baeyens *et al.*, 2015; Myria, 2017).

3. Pathways to (oral) health inequalities

Oral diseases are multifactorial. Literature provides strong evidence showing that dental caries is positively correlated to sugar intake and adversely correlated to tooth brushing with fluoridated toothpaste (Chaves & Vieira-da-Silva, 2002; Moynihan, 2016). However, dietary and behavioural determinants of caries are correlated with people's social context, resulting in worsened oral health outcomes in underprivileged groups.

Table 0.2 shows several social determinants to define underprivileged individuals or people at risk to live in deprivation. In all of the indices, professional status and housing seemed to be dominant criteria. So, unemployment and lack of decent housing seem to conduct people towards a lower

socio-economic position. Further, this lower socio-economic position is related to worse oral health outcomes and more health-compromising behaviour. This deduction inevitably leads us to a very important question: **why this link**?

According to the 'Black report', the existing social gradient in health can have different explanations (Townsend & Davidson, 1982). The "artefact theory", stating that the observed social gradient is purely a matter of observational bias and methodological errors, is the least plausible explanation. As mentioned before, there is substantial evidence to confirm the existence of a health gradient in most countries worldwide. A second explanatory theory is the "selection theory", suggesting that deprived health leads to decreased social mobility and so to a lower socio-economic position. This hypothesis comprises both intra-generational and inter-generational selection. The first aspect puts emphasis on the fact that a less healthy individual is less likely to obtain a higher socio-economic position in adult life, while inter-generational selection describes the cumulative effect of health on social mobility over generations. However, health inequalities can also occur following the opposite direction: the "causation theory" supposes that material and structural deprivation (housing, resources), as well as differences in life style, will lead to worsened health outcomes. Probably, a combination of both causation and selection can be suggested to declare the existing social gradient in health.

It is very difficult to determine the specific **onset** of health inequalities. What is clear, is that considering "the presence or absence of disease" as the only marker of health inequalities will lead to symptomatic approaches, which do not avoid or eliminate social inequalities. Indeed, even in countries providing universal access to health care services, socio-economic gradients persist (Mackenbach *et al.*, 2008). Novel insights in medical research have shown that adult conditions cannot be exclusively attributed to adult health behaviour. Early childhood conditions and even prenatal processes play an important role in the occurrence of various psychic and somatic diseases in later life, such as pulmonary and cardiovascular disease, vaginal and cervical cancers, schizophrenia, autism and cognitive development disorders (Colley *et al.*, 1973; Hatch *et al.*, 1998; Shonkoff *et al.*, 2000; Bateson *et al.*, 2004; Colborn, 2004; Barker *et al.*, 2005; Opler & Susser, 2005; Rapoport *et al.*, 2005; Kolevzon *et al*, 2007; Nomura *et al.*, 2007). Shonkoff *et al*. (2007) stated that negative childhood experiences can affect adult health in two different ways: repeated adverse conditions can have a cumulative effect over time or adversities during sensitive developmental periods can be biologically embedded and expressed after many years.

Further in life, Gomaa *et al*. (2016) summarized the impact of hormonal changes in chronic disease. They concluded that socio-economic position and financial stress are related to higher levels of stress hormones, disrupted immune biomarkers and increased bacterial load. They suggest potential interdependencies between social and biological determinants, leading to poorer oral health.

Even if the influence of stress hormones partially explains changes in oral health, the biological link with oral health behaviour is less clear. Why are unemployed people more likely to neglect their oral health? Why do they avoid dental visits and why do they brush less frequently their teeth?

Mullainathan and Shafir (2013) published a renowned book, "*Scarcity: Why having too little means so much*", combining research from behavioural sciences and economics. **Scarcity** is not defined as a pure matter of material deprivation, but it also comprises lack of time, lack of social support and others. Scarcity leads to stress, and this stress influences behaviour, possibly resulting in harmful choices. The authors compared this situation with a computer, running ten heavy programs at once.

The device will get slower, make errors and even crash, not because it's a second-class computer, but because it is overloaded. People in deprivation experience a comparable situation. They do not act less intelligently because they are not intelligent, but because they live in a context in which anyone would act less intelligently. Accordingly, the hard-working business man, living on the edge of a burn-out, can also lose his perspicacity and insight due to lack of time, sleep deprivation and work load. For him, every demand starting with *"Can you please…"* can be perceived as overwhelming and insurmountable, regardless of how simple the question might seem from an external point of view. However, there is one crucial difference between social and material deprivation and work overload, how hard they both might be: you cannot "take a day off" to escape from social deprivation.

There is scientific evidence to prove that the mental processes within people in deprivation are put under pressure due to scarcity, and **deprivation can lead to loss of IQ** (Mani *et al.*, 2013). People in material deprivation lose the capacity of focussing on other problems due to cognitive occupation. Mani *et al.* set up an experiment involving an African tribe of which the members received their entire year's salary at the time of harvest in June. Right after harvest, the tribe members were wealthy, whether they experienced deprivation in the last months before the next harvest. In both periods, they were asked to solve the same cognitive tests, showing that cognitive scores were significantly better during the wealthy period and so demonstrating that lack of wealth affects intelligence.

The effect of scarcity on cognitive function might counter the statement that oral health-related behaviour is exclusively a matter of free-choice acting. Instead, oral health behaviour and oral health in general are largely affected by social networks and social support, defined as '**social capital**' (Rouxel *et al.*, 2015). Bernabe *et al.* (2011) demonstrated a negative correlation between dental caries in adolescents and social support, a relationship which was independent of demographic parameters, socio-economic variables and oral health behaviour. However, support from one special person seemed to be more relevant for adolescent caries experience than family or peer support.

The important role of a supportive environment is not that illogical. The Institute of Medicine report (2010) stated that "*it is unreasonable to expect that people will change their behaviour easily when so many forces in the social, cultural, and physical environment conspire against such change*". As an example, it is obvious that smoking cessation is easier in a supportive environment without other smokers than it would be when being surrounded by chain smokers. For health promotion, social context should always be considered and integrated in possible interventions. The WHO (2005) recognised that interventions which only tackle adverse health behaviours will have little success, since they "*only offer micro-environmental solutions to a macro-environmental problem*". This conclusion was reinforced by an analysis of dental health education by Watt (2007).

Solar and Irwin (2010) presented a model, the WHO CSDH conceptual framework, making a distinction between *structural* determinants of health inequalities (the socioeconomic context and policy, leading to a certain social hierarchy) and *intermediary* determinants, referring to individual circumstances and disease risks, in terms of material deprivation, behavioural and psychosocial factors. This model was adapted to the situation of oral health inequalities by Watt and Sheiham (2012) (fig. 0.2).

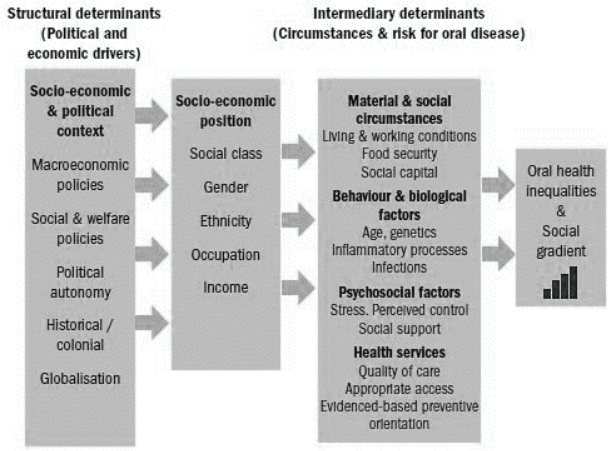

Fig. 0.2: Conceptual model for oral health inequalities (Source: Watt and Sheiham 2012)

4. Theoretical framework to reduce (oral) health inequalities

In order to facilitate policy interventions, Whitehead *et al.* (2001) illustrated the different health determinants in a concentric "rainbow" model with the individual in a central position (fig. 0.3). The individual, with his characteristics and constitutional factors is surrounded by different health-influencing factors, which can be affected by health promoting interventions.

The inner circle illustrates the individual behaviour and lifestyle, which clearly play a decisive role in people's health. However, individuals don't live in a social vacuum, there is an interaction with family, friends and neighbourhood. These daily interactions can influence health, both in a positive and negative way. The next layer consists of environmental factors, which involve the "facilities" to make healthy choices, such as working and living conditions, healthy food supply, access to health care services and education. Finally, all layers are embraced by the macro-economic, cultural and ecological conditions of a country or region. These general conditions can have a supportive or restrictive impact on the underlying circles.

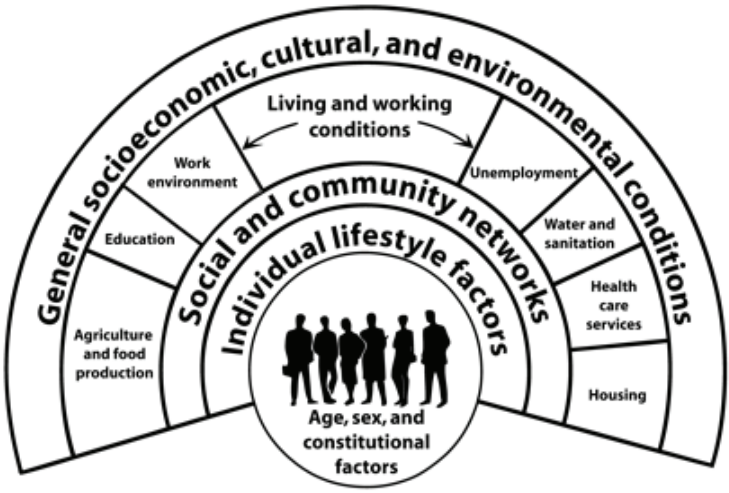

Fig. 0.3: The rainbow model according to Whitehead et al. (2001)

It would be narrow-minded to believe that the determinants in this concentric model only affect one health outcome at the time. Most of the social determinants and lifestyle factors influence the entire spectrum of people's health. However, the dominant approaches in health promotion tend to put emphasis on reducing one specific disease, neglecting the considerable number of risk factors which most diseases have in common. In the case of oral health, this approach leads to a disconnection of oral health from general health. **The common risk factor approach (CRFA)** is a more inclusive approach to tackle risk factors common to a number of major chronic diseases, including oral diseases (Sheiham & Watt, 2000). There is a strong association between oral diseases and a number of major chronic diseases, sharing "common risk factors", such as consumption of free sugars, bacterial load, smoking, and drug and alcohol abuse (Watt & Sheiham, 2012). This undeniable link with general health highlights the need for combined preventive actions in a multidisciplinary approach, tackling common-shared health compromising factors in the most efficient way. It is indispensable to work in partnerships with health workers from other sectors and disciplines and to integrate oral health aspects into general health promotion programs.

Another reason to stimulate multidisciplinary interventions is linked to the early onset of health inequalities. Since early life events and even prenatal conditions, such as smoking or having periodontitis during pregnancy, have an undeniable impact on childhood and adult health outcomes, interventions should start as early as possible (Shonkoff *et al.*, 2007). For oral health promotion, this means that interventions should already start long before the appearance of the first primary tooth. Consequently, preventive oral health care needs to be included into both antenatal and postnatal care.

Reducing socio-economic health inequalities cannot exclusively be delegated to the health sector and social organisations. The CRFA does not only focus on deficient health behaviour on itself, but also considers the common underlying determinants of health, in order to improve the overall health of populations and to reduce social inequalities. In this way, reducing oral health inequalities requires "*strategic, concerted, and bold actions at local, national, and global levels*" (Lee, 2014). The oral health inequality problem is just one aspect within the broader spectrum of social inequalities. This implies that oral health promotion needs to be part of a broader range of community actions, which is more than health promotion alone. The social capital, including environmental and community forces, is a significant determinant of improving health (Syme, 2004).

Policy makers and stakeholders can facilitate the reduction of (oral) health inequalities by taking proper actions. The WHO provided important policy guidelines in this respect, by means of the **Ottawa Charter for Health Promotion (WHO, 1986)**. The principal bullet points of this charter are:

- Establish healthy public policy: the cause of all causes is social inequality, which needs to be tackled by policy measures, comprising economy, equal education, employment and others.
- Create supportive environments, by making the healthiest choice the easiest choice. Therefore, in (oral) health promotion, a key role is assigned to local communities and organisations in different fields to plan social environments which support health-promoting choices, and help to effectuate the reduction of social and health inequalities (Moysés *et al.*, 2014).
- Strengthen community action, by involving all relevant social actors in the process of decision making and implementation of (oral) health promotion strategies, both on local and national scale.
- Develop personal skills, enabling people to have control over their health.
- Reorient health services to make sure that the structure and type of care provision, as well as the payment system, correspond to the health needs of the population. This patient-centred care should find a good balance between private institutions and public health centres.

For stakeholders, it is important to underline that early childhood programs can have an impact on later adult life. Effective interventions for low-income children also reduce governmental costs, by enhancing greater economic productivity, reducing welfare dependence and lowering the rates of imprisonment (Campbell & Ramey, 1994; Yoshikawa, 1994; Schweinhart, 2005). The **Marmot review (2010)** stresses the importance of **education and employment** in improving people's standards of living. Marmot's vision to reduce health inequalities can be compressed into six key points:

- Give every child the best start in life
- Enable all children, young people and adults to maximize their capabilities and to have control over their lives (empowerment)
- Create fair employment and good work for all
- Ensure healthy standard of living for all
- Create and develop healthy and sustainable places and communities
- Strengthen the role and impact of health prevention

5. The Belgian situation

5.1 Existing knowledge on oral health inequalities in Belgium

Socio-economic oral health inequalities in Belgian pre-school children have already been extensively reported. Van den Branden *et al.* (2013) did not only highlight the occurrence of **early childhood caries (ECC)** in preschool children (3-5 years old), but also provided some evidence that a social gradient in early childhood caries can be suggested. The authors confirmed earlier findings from "Niets aan de Tand", an oral health project in a group of preschool inner-city children, revealing that ECC was strongly associated with ethnicity and neighbourhood (Willems *et al*., 2005; Martens *et al.*, 2006). Living in a deprived neighbourhood and having a mother of Eastern European origin were the most significant predictive social determinants of ECC. Also the professional status of the mother was correlated with the children's oral health. ECC was present in 7.4% of the children having a mother from the highest professional class, 15.6% in the middle class group and 29.6% in the lowest professional class group.

Most national reports on oral health aspects only include preschool children. Recent data from children attending school and adults are rather scarce. Vanobbergen *et al*. (2001) saw an inverse association between the caries risk of 7-year-old children and the occupational level of their parents. De Reu *et al.* (2008) could demonstrate that the oral health behaviour and care index of a sample of socially deprived adolescents between 12 and 26 (n=68) was significantly affected by their living conditions.

Regarding **head and neck cancer** in Belgium, including oral cavity cancer, Hagedoorn *et al.* (2016) demonstrated socio-economic disparities in mortality rates. Social inequalities appeared both between individuals and between areas. **Smoking**, one of the principle risk factors of oral cancers and periodontitis, is not equally distributed either. The Belgian Foundation against Cancer interviewed a representative sample of the Belgian population (n=3000) on smoking habits, showing 20% of the Belgian adults to be smoker, and 17% smoked on a daily base (Stichting tegen Kanker, 2017). However, there were more smokers within the group of unemployed individuals (39%), compared to the labourer group (30%), the self-employed (20%), employees (14%) and higher staff personnel (13%), confirming the social gradient in health behaviour. Remarkable is that 73% of the smokers reported to regret the fact that they ever started smoking, 65% wanted to quit smoking and 74% would dislike it if their children would also smoke.

Dietary habits are also related to socio-economic determinants. The "Health Behaviour of School aged Children" (HBSC) survey previously demonstrated a social gradient in **obesity** in French-speaking Belgian adolescents (Coppieters *et al.*, 2002). De Coen *et al.* (2012) found SES-differences in **soft drink consumption** in Flemish preschool children, mediated by three main parenting practices: accessibility of soft drinks during warm meals, availability of soft drinks at home and permissiveness towards soft drinks consumption. Marro *et al.* (2018) found a relationship between the presence of **erosive tooth wear** and educational level in Flemish adolescents. Following a technical/vocational type of education was associated with an odds ratio of 1.49 (95%CI=[1.03–2.13]) to show erosive tooth wear.

In Flanders, the number of general dentists is decreasing and the dental practitioners are ageing. In 2017, the estimated number of qualified dentists was 1 per 1,147 residents in Belgium and 1 per

1,182 in Flanders (http://www.dekamer.be/QRVA/pdf/54/54K0138.pdf, p261). When the number of dentists decreases, it can be assumed that the "law of demand and supply" will not be beneficial to vulnerable subgroups in society. To cope with the decreasing number of dentists, and to emphasise the importance of preventive oral health care, a new curriculum for dental hygiene education has been established in Flanders in 2016: 'Bachelor in Oral Care'. Until present, Belgium has no experience with dental hygienists as part of the professional dental team.

5.2 Governmental initiatives

In Belgium, government invested in (oral) health care by introducing a universal health care insurance coverage in the 1960's, aiming to reduce the barriers to access for (oral) health care for all layers of the population. Many oral health care services are covered for 75-80% by a **compulsory health care insurance**. To reduce inequalities in (oral) health, some national governmental initiatives have been implemented. Underprivileged individuals can be entitled to an **increased allowance** for health care interventions when the annual family income is lower than €18,730.66, increased by €3,467.55 for every additional family member (limit calculated for 2017). In this case, basic dental care is covered for 100%, provided that the dentist did not count supplements and acceded to the convention between the national health insurance agency and dental professional organisations. The measure of increased allowance is not always automatically assigned. In these cases, individuals should apply for it.

In case of excessive medical costs, less fortunate people can also have access to the mechanism known as the **"Maximum Bill"**, calculating a cost limit for medical care. All medical costs exceeding this limit will be completely reimbursed. The cost limit is not a fixed threshold, but fluctuates according to the family income. Table 0.3 shows the cost limit per income level.

Apart from increased allowance and Maximum Bill, a full coverage of regular treatment costs for all children under the age of 18 is guaranteed, provided that the dentist acceded to the convention between the national health insurance agency and dental professional organisations. In 2017, 59.6%% of Belgian dentists partially or completely took part in this convention. In Flanders, this was 55.45% (http://www.dekamer.be/QRVA/pdf/54/54K0138.pdf, p261).

Annual net family income	Cost limit
Every resident under 19 years old	€663
0 - €18,231.97	€459
€18.231,98 - €28.028,25	€663
€28.028,26 - €37.824,56	€1.020
€37.824,57 - €47.212,66	€1.428
> €47.212,67	€1.836

Table 0.3: medical cost limit (Maximum Bill), based on family income level (2017-01-01)

In general, a **fee-for-service method** is used in oral health care provision. In this system, a patient pays the entire dental visit cost to the dentist at first hand, in order to recover at second hand the biggest part of this sum from his health insurance agency. A **third-party payment** is allowed for

minors and individuals entitled to an increased allowance. In this system, a patient does not have to advance the entire dental fee, but only the non-covered part of it. The insurance agency pays the reimbursed part of the fee directly to the dentist. However, third-party payment is not automatically applied. It is up to the dentist to decide if he/she wants to work with it or not.

GENERAL AIM AND OBJECTIVES OF THE STUDY

The literature review in the introduction section demonstrated the existence of persisting oral health inequalities worldwide, appearing in a graded pattern (social gradient). The association between socio-economic status and oral disease seemed to be stronger in high-income countries, suggesting that social disparities must be found in Belgium too. Although, recent data on the Belgian situation are rather scarce, especially from school children and adults. Furthermore, apart from detecting oral health inequalities, it is important to look for specific interventions in order to reduce them and to deal with the existing gaps in international literature.

The general aim of the study is to assess oral health inequalities in Belgium, and to gain better understanding of measures dealing with social disparities.

The more specific objectives derived from the general aim are summarized per chapter:

Chapter I:
to explore oral health inequalities and to assess the impact of socio-economic factors on oral health, oral health behaviour and dental attendance of primary schoolchildren.

Chapter II:
to explore the possible relationship between caries experience and social indicators, within a representative sample of Belgian adults, in order to improve targeted policy interventions.

Chapter III:
to review the international literature on existing interventions targeting oral health inequalities as a measurable outcome.

Chapter IV:
to evaluate the impact of a 4-year longitudinal oral health promotion program on oral health and oral health-related knowledge of primary schoolchildren and on reducing inequalities in child oral health outcomes.

Chapter V:
to develop and pilot-test a preventive and curative oral health care path, mediated by Community Oral Health Workers (COHW's), targeting underprivileged individuals.

CHAPTER I

Socio-economic inequalities in caries experience, care level and dental attendance in the last grade of primary school in Flanders, Belgium: a cross-sectional survey

LAMBERT M.[1], VANOBBERGEN J.[1], MARTENS LC.[2], DE VISSCHERE L[1]

[1] *Department of Community Dentistry and Oral Public Health, Dental School, Ghent University, Belgium*
[2] *Department of Paediatric Dentistry and Special Care, Dental School, Ghent University, Belgium*

This chapter is an edited version of the manuscript, which was published in ***BMJ Open*** on 2017-07-20*:*
Lambert MJ, Vanobbergen JNO, Martens LC, De Visschere L (2017): Socio-economic inequalities in caries experience, care level and dental attendance in primary school children in Belgium: a cross-sectional survey BMJ Open 7:e015042. doi: 10.1136/bmjopen-2016-015042

Abstract

Objectives: this chapter aims to explore oral health inequalities and to assess the impact of socio-economic factors on oral health, oral health behaviour and dental compliance of schoolchildren in the final grade of primary school.

Methods: data collection was executed in 2014 within a sample of 2,216 children attending the final (sixth) grade of primary education in 105 primary schools in Flanders, by means of an oral examination and a validated questionnaire. The Inter-mutualistic Agency (IMA) database was consulted to objectively determine individuals' social state and frequency of utilisation of oral health care services. Underprivileged children were compared to more fortunate children for their mean DMFT, DMFS, Plaque index, Care Index (CI), Restorative Index (RI), Treatment Index (TI), knowledge and attitude. Differences in proportions for dichotomous variables (RI100%, TI100% and being a regular dental attender) were analysed. The present study was approved by the Ethics Committee of the University Hospital Ghent and all parents signed an informed consent form prior to data collection.

Results: underprivileged children had higher D_1MFT (Mean diff: 1.12; 95%CI=[0.87-1.36]), D_3MT (Mean diff: 0.47; 95%CI=[0.30-0.64]) and plaque scores (Mean diff: 0.17; 95%CI=[0.12-0.23], and lower care index (Mean diff: 11.87; 95%CI=[4.47-19.27]) than the other children. In the low-income group, 78.4% was caries-free, compared to 88.4% of the other children. Half of the low-income children could be considered as regular dental attenders, whether 12.6% did not have any dental visit during a five year period.

Conclusion: oral health, oral hygiene, oral health care level and dental attendance patterns are negatively affected by children's social class, leading to oral health inequalities in Belgian sixth grade primary school children.

Introduction

Although dental caries is largely preventable, it is a major public health problem, since untreated tooth decay remains by far the most common chronic disease worldwide (Marcenes *et al*., 2013). International data on childhood caries epidemiology confirm that dental caries remains a '*significant and consequential disease of childhood*', being increasingly localised in high-risk children, both in developing and developed countries (Edelstein, 2005).

Dental caries is a multifactorial disease. Consumption of sugary substances and poor oral health practices largely affect the occurrence of tooth decay. Literature provides powerful evidence that dental caries is positively correlated to sugar intake and adversely correlated to tooth brushing with a fluoridated toothpaste (Chaves & Vieira-da-Silva, 2002; Moynihan, 2016). However, all dietary and behavioural determinants of caries are influenced by people's social context, resulting in worsened oral health outcomes in underprivileged groups. Socio-economic inequalities in pre-school children have already been reported nationally and internationally. Van den Branden *et al.* (2013) not only highlight the occurrence of early childhood caries in preschool children (3-5 years old), but also provides some evidence that a social gradient in early childhood caries can be suggested. This confirms results from earlier national reports and is consistent with international literature (Edelstein, 2005; Willems *et al.*, 2005; Declerck *et al*., 2008; Do, 2012). For the Belgian situation however, the mentioned national reports only include preschool children. Recent data from children attending school are scarce, but certainly needed (Vanobbergen *et al*., 2001).

The occurrence of dental caries and other oral diseases is not the only domain in which inequalities appear. Use of oral health care facilities and regular preventive dental check-ups are also affected by social variables. In adulthood, it is clear that dental non-attenders rank significantly more often at the lower end of the socio-economic scale (Listl *et al.*, 2014[a]). Regarding the financial aspect of oral health care in Belgium, a fee-for-service payment method is used, combined with a compulsory health insurance. In this system, a patient pays the entire dental visit cost to the dentist at first hand, in order to recover at second hand the biggest part of this sum from his health insurance agency. To reduce inequalities in (oral) health, some national government initiatives have been implemented. Underprivileged individuals can be entitled to an increased allowance for health care interventions when the family income is low. In case of excessive medical costs, people can also have access to the mechanism known as the "Maximum Bill", calculating a cost limit for medical care for every individual. The higher the family income, the higher the cost limit. When medical costs exceed this limit, they will be entirely and automatically reimbursed. Furthermore, a full coverage of regular treatment costs for all children under the age of 18 is guaranteed, provided that the dentist acceded to the convention between the national health insurance agency and dental professional organisations.

Objective data on children's dental non-attendance and health consumption are scarce, not only in Belgium, but worldwide. By involving the Inter-mutualistic Agency (IMA) national database data on utilisation of (oral) health care services, this article provides objective information on oral health consumption and dental attendance.

In this study the authors aimed to explore existing oral health inequalities and to assess the impact of socio-economic factors on oral health, oral health behaviour and dental compliance of primary schoolchildren.

Materials and methods

Study design, settings and population

The present survey fits into the context of Glimlachen.be®, a prospective four-year longitudinal oral health promotion program, visiting primary schools in Flanders (Belgium) with a mobile dental unit. It is conducted by dentists of the Flemish Dental Association under the authority of the National Institute for Health and Disability Insurance (NIHDI).

The present cross-sectional study reports on the oral health condition of children in the last year of primary school, recruited in all schools in Flanders within the three educational networks (GO: publicly run under the authority of the Flemish Community (15%); OGO: publicly funded and publicly run by local authorities or provincial authorities (15%); VGO: publicly funded and privately run by private non-profit-making organisations, mainly catholic schools (70%)).

Data were collected in 2014 from a representative sample of 2,216 primary school children, attending the final (6^{th}) grade of primary education, in 105 different schools in Flanders. The total study population is estimated to be about 68,000 children in 2,340 schools. Schools were randomly selected, based on a two-step stratification. In the first step, a stratified randomisation was executed at school-level, based on three strata: number of pupils, region and educational network. In the next step, randomisation occurred at the individual level. There was an oversampling of 2% for schools with assistance from special education for disabled children or children with learning or educational difficulties. The sample size was determined based on a confidence level of 95% and a margin of error of 2.5%. There were several sample size estimations, depending on the variability of the different outcome variables. The authors decided to include as many children as practically possible, based on the availability of three mobile dental units and the number of school days.

Data collection

In all participants, oral health condition was recorded by visual inspection with a mobile dental unit in school premises by 44 trained and calibrated dentist-examiners. All examiners were blinded to the socio-economic status of the children they examined. Calibration was undertaken to avoid bias, using a series of full-mouth photographs simulating the clinical examination of patients, set up in a PowerPoint presentation. Intra Class Correlation Coefficient (ICC) for all examiners was 0.86 with a 95% confidence interval of 0.82 to 0.90. General kappa score was 0.72.

Individual children were examined for several oral health parameters. DMFT/DMFS was used as outcome variable to count the number of decayed (D), missing (M) and filled (F) teeth or tooth surfaces. Caries detection was based on the International Caries Detection and Assessment System (ICDAS), using six subcategories of caries going from first visible change in enamel (score 1) to extensive cavity with visible dentin possibly reaching the pulp (score 6). Both caries at D_1 level (score > 0: early enamel lesions and decay into dentine) and D_3 level (score ≥4: obvious decay into dentine, excluding early lesions restricted to the enamel) were taken into account. The level of provided care has been approached through the Restorative Index ($RI=(FT/(D_3+FT)) *100$), Care Index ($CI=(FT/(D_3+M+FT))*100$) and Treatment Index ($TI=((M+FT)/(D_3+M+FT))*100$), all ranging from 0 to 100%. The indices were also dichotomised to divide subjects into two groups: children without

untreated caries (RI=100%, CI=100%, TI=100%) and children with untreated caries (RI<100%, CI<100%, TI<100%).

Clinical amount of dental plaque was measured using the Plaque Index of Sillness and Löe (1964). This index calculates the mean buccal surface plaque score of six reference teeth on a scale from 0 (no plaque) to 3 (visible plaque on more than one third of the buccal surface).

Both knowledge and attitude were assessed by a validated and reliable questionnaire, answered by the children. A higher score out of ten correlates to more knowledge and a better attitude. An expert panel tested the content validity of the items, after which the questionnaire was pretested in a class of 25 primary school children (convenience sample) on two different time points (test-retest). Internal consistency was analysed by means of the Cronbach's Alpha, resulting in a score of 0.75, which fits into the required interval of 0.70<Cronbach's Alpha<0.90.

To explore the impact of social environment on oral health and oral health-related behaviour, knowledge and attitude, a summary measure was used to characterize the deprivation level. All parameters have been analysed in children eligible for the Maximum Bill for at least one year between 2009 and 2013, compared to those who cannot take part of this system (dichotomous explanatory variable). The Maximum Bill measure is automatically assigned to individuals in order to reimburse medical costs exceeding a certain limit, based on income levels. Accordingly, those who benefit from it correspond to underprivileged individuals. Those without can be considered as middle and high-income subjects. The combined questionnaire and oral health examination data were supplemented with the Inter-mutualistic Agency (IMA) national database data on utilisation of (oral) health care services, in order to trace individuals who can make use of the Maximum Bill and to obtain information on participants' frequency of utilisation of oral health care services. This includes all attested dental treatments and regular preventive dental check-ups over a period from 2009 to 2013. By consensus, participants are considered as regular dental attenders if IMA database reported at least one dental visit in three different years over a four-year period, excluding urgency treatments. Subsequently, a dichotomous variable has been created to distinguish regular dental attenders from non-regular dental attenders.

Data analysis

Data analysis was carried out in the IBM SPSS Statistics V22.0 (SPSS Inc., Chicago, IL, USA). Independent Sample T-test was used to compare underprivileged and more fortunate individuals for their mean DMFT, DMFS, Plaque index, Care Index, Restorative Index, Treatment Index, knowledge and attitude scores. A parametrical test was used, based on the central limit theorem. Differences in proportions for dichotomous variables (RI100%, TI100% and being a regular dental attender) were compared in crosstabs, using a Chi Square statistical test. Alpha was set at < 0.05.

The approach used to deal with uncomplete records and so to avoid bias, was to compare the proportion of children eligible for the Maximum Bill in both responders and non-responders (no clinical data available), by using the Chi Square statistical test. This social parameter could be determined for all children by using the national registration number of the child and the IMA database.

Ethical aspects

The present study was approved by the Ethics Committee of the University Hospital Ghent (B67020108008). All parents signed an informed consent form prior to data collection. All schools received information about the study protocol and agreed to participate. Children requiring dental treatment or periodic recall were referred to the local dentist.

Results

Sample consisted of 2,216 Flemish primary school children with a mean age of 11.25 years (SD=0.68). Data analysis was performed in 88.2% (n=1,954). Incomplete records were due to failure to obtain consent and child's absence from school on the day of examination. From these 1,954 children, 1,771 completed the questionnaire. Comparing the social status of responders and non-responders, the proportion of children eligible for the Maximum Bill was statistically equal for both groups (Chi Square Test; p=0.4).

More than 19% (n=374) of the children made use of the Maximum Bill. Being part of this subgroup significantly affected oral health and oral health behaviour, as demonstrated in table 1.1. Underprivileged children showed worse results for all outcome variables. They had a higher plaque index and higher DMFT and DMFS scores, both at D_1 and D_3 level. Overall care level was significantly lower, resulting in a lower Care Index, Treatment Index and Restorative Index. Both knowledge and attitude scores were slightly but significantly lower in low-income children.

Regarding the proportion of participants being completely treated for caries, underprivileged children again differed from their more fortunate counterparts. According to table 1.2, 78.4% of the low-income children were caries-free (DMFT=0), compared to 88.4% for the high-income group. From those having a DMFT>0, 55.3% of the Maximum Bill group children were found to have a 100%TI against 65.8% for children of higher social class. The same trend appeared when comparing the 100%RI and 100%CI, resulting in strongly significant differences. Half of the low-income children (50.3%) could be considered as regular dental attenders for the period between 2009 and 2013, whether 12.6% did not have any dental visit during these five year period. Middle- and high-income children visited the dentist on a more regular base, resulting in a 77.7% rate for regular dental attendance. Only 3.4% of these children did not report any dental visit. All of these differences proved to be statistically significant.

	Maximum Bill	N	Mean	SD	Mean diff.	95%CI	p-value
Mean Plaque index (missing = 1)	No	1602	0.41	0.48	-0.17	[-0.23;-0.12]	**<0.001**
	Yes	351	0.59	0.58			
DMFT (D_1-level) (missing = 1)	No	1601	1.68	2.05	-1.12	[-1.36; -0.87]	**<0.001**
	Yes	352	2.79	2.43			
DMFT (D_3-level) (missing = 2)	No	1600	0.78	1.42	-0.47	[-0.64; -0.30]	**<0.001**
	Yes	352	1.25	1.68			
DMFS (D_1-level) (missing = 0)	No	1602	2,30	3.25	-1.72	[-2.11; -1.32]	**<0.001**
	Yes	352	4,02	4.07			
DMFS (D_3-level) (missing = 0)	No	1602	1,18	2.51	-0.83	[-1.13; -0.52]	**<0.001**
	Yes	352	2,00	3.16			
Care index* (missing = 0)	No	544	70.33	42.14	11.87	[4.47; 19.27]	**<0.001**
	Yes	170	58.46	45.17			
Treatment index* (missing = 0)	No	544	73.13	40,83	8.34	[1.18; 15.51]	**0.02**
	Yes	170	64.79	43,75			
Restorative index* (missing = 0)	No	537	72.18	41.57	9.96	[2.54; 17.38]	**0.01**
	Yes	164	62.22	44,79			
Knowledge (missing = 183)	No	1483	7.58	2.12	0.80	[0.52; 1.07]	**<0.001**
	Yes	288	6.78	2.49			
Attitude (missing = 183)	No	1482	8.37	1.32	0.27	[0.10; 0.44]	**0.002**
	Yes	289	8.10	1.44			

Table 1.1: Oral health and oral health behaviour between children from low-income (utilising the 'Maximum Bill') and middle- and high-income children

*of those having DMFT>0

Variable	Maximum Bill		p-value
	No	Yes	
Treatment Index (TI=100%)^	65.8% (n=358)	55.3% (n=94)	**0.01**
Care Index (CI=100%)^	62.9% (n=342)	51.2% (n=87)	**0.001**
Restorative Index (RI=100%)^	65.4% (n=351)	53.7% (n=88)	**0.008**
Regular dental attender*	77.7% (n=1344)	50.3% (n=188)	**<0.001**
No dental visit between 2009 and 2013	3.4% (n=59)	12.6% (n=47)	**<0.001**
Caries-free proportion	88.4% (n=1414)	78.4% (n=276)	**<0.001**

Table 1.2: Dental Compliance and Caries-free proportions between children from low-income (using the Maximum Bill) and middle-to-high income families

^ Dichotomous explanatory variable

* at least one dental visit in three different years over a four-year period, excluding urgency treatments

Discussion

Oral health inequalities are clearly visible within the present sample of children attending the last grade of primary school. Since 2,216 subjects were randomly selected in 105 different primary schools in Flanders, results can be assumed to be representative of the entire Flemish region.

All included oral health parameters were strongly significantly affected by participants' social status. Not only caries experience (DMFT and DMFS) proved to be higher in underprivileged groups, but also oral hygiene (plaque index) and the level of care seemed to depend on families' social context. This level of care was assessed by means of the restorative index, care index and treatment index. These indices could only be calculated for children having a DMFT>0, since it is mathematically impossible to divide by "0", which would be the case for those having a DMFT =0. Also clinically, this would be irrelevant, because the indices aim to calculate the proportion of the decayed teeth which have been restored or extracted. If there is no caries experience at all, these indices are not applicable.

An arithmetic gap of 11.87, 8.34 and 9.96 emerges when comparing Care Index, Treatment Index and Restorative Index for middle/high-income and low-income children, in disadvantage of the latter group. The three indices do not all have the same meaning. Restorative Index (RI=(Ft/(D3+Ft))*100) does not consider the missing teeth, because there can be doubts whether teeth were removed due to caries or due to other factors (trauma, periodontal infection). Care Index (CI=(Ft/(D3+M+Ft))*100)

partially involves the missing teeth, but the index does not consider a tooth extraction as a 'solution', but as part of the problem. Children are literally 'missing' a tooth, so tooth extraction is seen as a 'lost chance'. On the other hand, Treatment Index (TI=((M+Ft)/(D3+M+Ft))*100) proposes tooth extraction as part of the solution, because it removes a (potential) focus of infection. It gives the same value to fillings and extractions. None of these indices can be considered as 'all-embracing', so it is good to compare them. When two subgroups differ significantly in RI, but not in TI, this means that one of the groups received more tooth extractions, which can be relevant to explore the severity of the disease and the way of treating it. The present findings suggest that the low-income children had more teeth being extracted, although it is hard to determine the clinical relevance of a 1% difference between Treatment Index and Restorative Index.

Statistical analysis clearly demonstrated underprivileged children to visit less frequently the dental practitioner. One out of eight low-income children (12.6%) did not see a dentist one single time during the five years prior to data collection. This dental absenteeism is almost four times higher in underprivileged groups compared to the more fortunate subgroups.

The present Flemish results on oral health inequalities are not a unique phenomenon, but are in accordance with global findings. International literature is overloaded with recent evidence demonstrating social inequalities in oral health. A systematic review by Schwendicke *et al.* (2015) shows that low social class is associated with an increased risk of dental caries, especially in more developed countries. Childhood financial hardship not only has a main impact on individuals oral health during childhood, but also in later life. Poulton *et al.* (2002) revealed that low childhood socio-economic status (SES) contributes to increased adult levels of caries and periodontal disease, even after adjusting for adult SES. Listl *et al.* (2014[b]) confirmed these findings, showing the long-term adverse effects of financial problems in childhood on oral health in middle and later adulthood.

The todays' persistence of social inequalities, both in Flanders and in the entire world, is food for thought. One could state that all previous oral health promotion campaigns, health promoting schools and governmental interventions could not close the social gap in oral health. Unfortunately, the present cross-sectional survey is not able to uncover a specific reason for the persistence of inequalities and neither can determine whether the situation is improving or deteriorating. What needs to be considered and further investigated, is the key role played by the family and environmental context in children's dental adherence. It is clear that 12-year old children cannot be taken fully responsible for being a dental non-attender. A systematic review revealed that parental oral health habits affects children's oral health (Castilho *et al.*, 2013). For this reason, the authors of this review state that oral health promotion programs need to put emphasis on the entire family context, concerning their lifestyle and oral health behaviour.

Regarding the financial aspect, basic dental costs are completely reimbursed in Belgium for all children under the age of 18 without distinction, so in fact differences in utilisation of health care services for financial reasons should not be expected. However, in most dental practices, the often high dental fee needs to be paid first by the client "out of pocket", to get it reimbursed by the health insurance agency afterwards. Third-party payment, in which the health insurance agency pays the dental fee directly to the dental practitioner instead of the client, is allowed for all minors, but not well-established. Further, 37.36% of the Belgian dentists did not take part in the fee convention, bearing a risk of potentially increased dental costs. The authors cannot draw conclusions in this

respect, but want to express the need to determine the principal cause(s) of oral health inequalities. The specific provider payment method can be one of the factors, but probably not the only one. Regarding knowledge and attitude of the children in this study, there are statistically significant differences between both social subgroups. However, a mean difference of 0.27 in attitude (on a score out of ten) might be of little clinical relevance to explain the existing inequalities. For children's knowledge, the gap is bigger, with a mean difference of 0.80 in knowledge scores. Differences in knowledge and health literacy, attitude and lifestyle need further investigated, not only for children, but also for parents.

Although oral health inequalities have always existed and are still remaining, society cannot simply acquiesce in its existence. Dental caries is largely preventable, but still remains the most prevalent chronic disease worldwide, mainly affecting high-risk subgroups (Marcenes *et al.*, 2013; Kassebaum *et al.*, 2015). Dental treatment is expensive, absorbing a considerable part of overall health care budget (Listl *et al.*, 2015). Watt *et al*. (2015) call in the "London Charter on Oral Health Inequalities" for a more upstream public health approach, targeting the deeper social, political and economic causes of oral health inequalities. They advocate new multidisciplinary preventive strategies at local, regional, national and international levels, based on a common risk factor approach. Quoting the authors: "*collaborative efforts among researchers, policy makers, public health practitioners, clinical teams, and the public are urgently required*". So, decisions on oral health promotion and tackling oral health inequalities should not exclusively be made by policymakers, but also involve dentists and intermediate partner organisations.

The 'Marmot Review' provides a guidance to assess the social gradient in health, by introducing the method of 'proportionate universalism' (Marmot, 2010). Interventions don't need to focus only on the most disadvantaged individuals, but should be universal and contain a scale and intensity in accordance with subgroups' level of disadvantage.

The authors understand that the oral health status of Belgian children might be of less relevance in international literature. Although, this survey describes a very relevant theme: social inequalities in health. Off course, many other authors did research on this topic. However, the present study certainly has an added value. What pleads in favour, is the large sample of children with the same age, but more important, the objective and reliable link that was provided between children's oral health, their social status and their oral health care utilisation. Oral health was investigated by calibrated and blinded dentists. Afterwards, these findings were linked to people's social class, not by interviewing the patients or their parents, but by exploring data of the national health institute. In this way, dental examiners were blinded, and people could not 'hide' their social status for the researchers. Furthermore, the same database revealed the most reliable information on oral health care utilisation. Mostly, dental attendance is assessed by means of a questionnaire, inevitably leading to bias. In this survey, every single dental visit of a child could be linked to its corresponding record. It is obvious that this kind of survey requires a strict procedure, to ensure children's medical data and privacy. Because of the sensitive character of the information, studies with the same setting are very rare. A literature search on PubMed with the following string "Oral Health"[Mesh] AND "health care utilisation"[All Fields]" resulted in only 7 hits. Two Nigerian surveys reported on almost the same subject, but both of them used a self-administered questionnaire (Aiayi & Arigbede, 2012; Onyejaka *et al*., 2016).

The authors also have to report some limitations of the study. Although oral health figures can be comparable with other western countries, the present sample only included Belgian subjects. Further, the cross-sectional study design does not allow the authors to identify specific causes for inequalities in oral health and dental non-attendance, only associations.

Since Glimlachen.be® is a four-year longitudinal program visiting schools, most of the subjects will have received previous dental screenings before the present data collection. These screenings might have positively influenced the oral health and oral health behaviour of all children, resulting in an underestimation of oral health-related problems. However, this influence should be equal for both compared groups.

Conclusion

Oral health inequalities are an undeniable reality in sixth grade primary school children in Flanders, Belgium. Oral health, oral hygiene, oral health care level and dental attendance patterns are negatively affected by children's social class.

CHAPTER II

Social gradient in caries experience of Belgian adults 2010: a cross-sectional survey.

LAMBERT M.[1], DE REU G.[1], DE VISSCHERE L.[1], DECLERCK D.[2], BOTTENBERG P.[3], VANOBBERGEN J.[1]

[1] *Department of Community Dentistry and Oral Public Health, Dental School, Ghent University, Belgium*
[2] *KU Leuven Department of Oral Health Sciences, Population studies in Oral Health, Leuven, Belgium*
[3] *Oral Health Research Cluster (ORHE), Free University Brussels, Belgium*

This chapter is an edited version of the manuscript, which was accepted for publication in ***Community Dental Health*** on 2017-12-29

Abstract

Objective: this study aims to explore the caries experience of the Belgian population in relation to social parameters.

Methods: data collection (2009-2010) consisted of an oral health interview (self-administered questionnaire, pre-tested and validated) and an oral health examination during a home visit. Data were collected from a representative sample of the Belgian population (>5 years old). Only the economically active population was included for final analyses. ANOVA and multivariable regression analyses were used to reveal associations between social parameters, oral hygiene, untreated decay, DMFT and edentulousness.

Results: 2,742 participants completed the questionnaire, a clinical oral examination was done for 2,563 participants. More than half (53% (N=1,392)) were female and mean age was 43.3 years (95%CI=[41.2-45.4]). In the total population, mean DMFT was 10.8 (95%CI=[10.0-11.5]). In the analysed subsample, higher educated subjects had lower DMFT scores than those with primary school as highest degree or without diploma (p=0.003). Employment status was associated with the presence of untreated tooth decay, especially in the youngest age group (p=0.015), and also with edentulousness (p=0.02), with a higher risk among unemployed women of being completely edentulous (OR=5.32; 95%CI=[1.75-16.12]). Untreated tooth decay was related to frequency of tooth brushing and plaque index (p<0.002 and p<0.001 respectively).

Conclusions: socio-economic disparities in oral health are present in Belgian adults. Caries experience, expressed as mean DMFT and proportion of untreated tooth decay, is more associated with level of education and employment status than with family income, which is still the main criterion in Belgian health care organisation.

Introduction

More educated and affluent persons live longer and are healthier on average than less educated and underprivileged individuals, indicating that the health of an individual is influenced by social parameters (WHO, 2008). The same pattern applies to oral health. Various national and international reports show that the prevalence of oral diseases is not equally distributed, despite their widespread occurrence (Sabbah *et al.*, 2007; Vanobbergen *et al.*, 2010; Costa *et al.*, 2012). Socio-economic oral health inequalities and social gradients exist in most countries, resulting in subgroups in society whose members are at greater "risk" of experiencing severe caries and periodontal diseases (Sanders *et al.*, 2006). This association between low socio-economic status and oral diseases seems to be stronger in high-income countries (Schwendicke *et al.*, 2015).

Oral health inequalities can be considered as unfair systematic differences in oral health among populations in society judged to be avoidable by reasonable action. Solar and Irwin (2010) argue that health inequalities are determined by patterns of social stratification arising from the systematic "*unequal distribution of power, prestige and resources among groups in society*". The unequal distribution of these factors is not only associated with worse health outcomes, there also seem to be clear socio-economic gradients in health behaviour, showing people with lower educational levels reporting a higher frequency of health-compromising behaviours (Singh *et al.*, 2013).

The existence of a social gradient means that oral health risks do not have an on/off-switch but rather appear as a continuum. The most underprivileged groups are at highest risk, while the wealthiest groups have the lowest risk (which is, however, never reduced to zero). There are several possible explanations for this gradient, according to the 'Black report' (Townsend & Davidson, 1982). The "artefact theory", stating that the observed social gradient is purely a matter of observational bias and methodological errors, is the least plausible explanation. A second explanation theory is "selection theory", according to which poor health leads to decreased social mobility and so to a lower socio-economic position. This hypothesis comprises both intra-generational and inter-generational selection. The former emphasises the fact that a less healthy individual is less likely to obtain a higher socio-economic position in adult life, while inter-generational selection describes the cumulative effect of health on social mobility over generations. However, health inequalities can also follow the opposite direction: "causation theory" holds that material and structural deprivation (housing, resources), as well as differences in lifestyle, will lead to worsened health outcomes. Probably, a combination of both causation and selection are involved in the existing social gradient in general and oral health.

In Belgium, universal health care insurance coverage was introduced in the 1960s with the aim of reducing the barriers in access to (oral) health care for all layers of the population. The cost of 75-80% of many oral health care services is covered by compulsory insurance. For children and vulnerable persons, a full reimbursement of the standard care package is guaranteed. Furthermore, a third-party payment can be applied for these two groups, which is forbidden for all other residents. However, in health care policy and organisation, being vulnerable is almost exclusively based on financial determinants, in particular family income. Belgian residents can be entitled to the increased allowance for health care interventions when the annual family income is lower than €18,730.66, increased by €3,467.55 for every additional family member. Although, there might be other factors which could describe residents' social context, such as educational level, employment and origin

(Jarman, 1991). For this reason, the present study aims to explore the possible relationship between caries experience and oral hygiene behaviour, and a broad range of social indicators, within a representative sample of Belgian adults, in order to improve targeted policy interventions. The survey was commissioned by the National Institute for Health and Disability Insurance (NIHDI) of the Belgian Federal Government.

Methods:

The data included in the study were derived from the Belgian Oral Health Data Registration and Evaluation System (OHDRES 2009-2010). This exercise was conducted by the Interuniversity Consortium of Epidemiology. It consisted of both a health interview survey (data obtained by means of a self-administered questionnaire) and a health examination survey (data obtained by means of an oral examination executed by a trained and calibrated dentist-examiner during a home visit). All data were collected between September 2009 and November 2010. More details about the methodological aspects of this survey have been previously published (Declerck *et al.*, 2013). Research protocols were approved by the Research Ethics Committee of Ghent University Hospital (Protocol B67020071382, approved March 8, 2007).

The target population consisted of all persons (> 5 years old) listed in the National Register of Belgian residents. For practical reasons, prisoners, residents of a religious community consisting of more than eight people and other institutionalised persons (except residents of nursing homes and residential care centres) were excluded. A multi-stage, stratified clustered sampling technique was used in order to obtain a representative sample of the Belgian population aged 5 years and older with a 10% oversampling of persons 75 years and older. The sampling stages were: region, province, municipality and finally households. Households were ranked hierarchically by statistical sector (territorial subdivision of a municipality), household size and age of the reference person (head of household) (Statistics Belgium, 2012). In Belgium, population data are most readily available on household level. For that reason, the basic sampling unit in the present study was the household, although the unit of analysis was the individual participant.

The self-administered questionnaire appeared in either Dutch, French or German, depending on the official language of the locality. It comprised 34 questions covering several domains: oral hygiene habits, barriers to dental attendance, dietary habits, oral health-related impairments, oral health-related quality of life, tobacco use, general health, educational level and employment status. Oral health behaviour was recorded by means of self-reported frequency of tooth brushing: participants could report brushing their teeth “twice or more per day”, “once a day”, “less than once a day”, “never” or “I don’t know”.

Explanatory variables consisted of gender and age and the following socio-economic parameters: educational attainment, employment, economic status (being entitled to increased allowance for health costs), nationality and country of birth. The last two parameters were categorised in 3 subgroups: “Belgium”, “other West European countries including USA, Canada and Australia” and “other countries”. Educational attainment was categorised as “primary or no diploma”, “lower secondary”, “higher secondary” or “higher education”. Employment was subdivided into four subgroups: “has a job”, “unemployed”, “retired” and “student”. Since retirement and attending school are determined far more by age than by social status, the retired and student subgroups were

excluded for further analysis on social parameters. For the same reason (to avoid bias), in the inferential analyses all subjects <18years old were excluded, because minors are not supposed to have a job or to have obtained a higher education degree. Accordingly, statistical analysis was restricted to economically active adults. All variables used in the analyses are summarized in table 2.1.

Oral health examination was conducted by 68 trained and calibrated dentist-examiners. Calibration was undertaken to avoid bias, using a series of full-mouth photographs simulating the clinical examination of patients, set up in a PowerPoint presentation. Five experts in epidemiological research established the benchmark for clinical examination to be used during calibration. For caries detection, $D_3MFT>0$ sensitivity was 99.6% and specificity 69%; for scoring the presence of plaque a sensitivity of 89% and specificity of 69% was obtained.

The clinical examinations were carried out by the dentist-interviewers in the participant's home, with the participants sitting on an ordinary chair, preferably in a well-lit room. The mouth was examined using a dental mirror and periodontal probe. Cotton rolls for removal of debris were available (disposable, sterile oral examination kit, Kerr®, Kerr-Hawe, Bioggio, Switzerland). The dentist-interviewers were equipped with a head lamp (Eijlander Electronics, Ede, the Netherlands) to improve visibility.

To measure caries experience, DMFT score was used as one of the outcome variables, summarising the number of decayed (measured at cavitation into dentine level (D_3), according to WHO criteria), missing and filled teeth (Klein *et al.*, 1938). Edentulous patients were considered to have a DMFT score of 28. Being completely edentulous was also separately analysed as a dichotomous parameter. The proportion of subjects with untreated decay was determined by considering the participants with a D component >0 and used as a dichotomised binary outcome variable in the analyses.

To evaluate the presence of dental plaque, the dental plaque score proposed by Sillness and Löe was used, calculating the mean buccal surface plaque score of six reference teeth on a scale from 0 (no plaque) to 3 (visible plaque accumulation on more than one third of the buccal surface) (Silness & Löe, 1964). Subjects with no natural teeth were excluded for this parameter. Subjects were dichotomised into a group having a plaque index of 0 and a group showing a higher amount of plaque (PI >0.0).

Independent variables	Type	Outcome variables	Type
Gender	Dichotomous	**Knowledge score**	Continuous [0-10]
Age	Ordinal	**Attitude score**	Continuous [0-10]
Educational attainment	Ordinal	**Self-reported frequency of tooth brushing**	Ordinal
Employment	Dichotomous	**DMFT**	Continuous [0-32]
Economic situation	Dichotomous	**Untreated caries (D>0)**	Dichotomous
Nationality	Nominal	**Plaque index (PI>0)**	Dichotomous
Country of birth	Nominal		

Table 2.1: Summary of the independent and outcome variables.

All analyses were weighted with sampling weights determined in terms of age distribution, gender and geographical location, to match the survey sample to the distribution in the entire Belgian population. All statistics (percentages, means, standard deviation,…) were weighted, except for the absolute numbers. Given the complex sample design of the study, the use of sampling weights is essential in the analysis. In addition, province was taken into account as a stratification factor and municipality as a cluster effect.

Baseline characteristics were summarized by using means, 95% CI and standard deviations or numbers of non-missing items with percentages, whichever was appropriate, for both the total population of the survey and the subpopulation of adults (≥18 years) with or without a job, being the economically active part of the study population. As mentioned earlier, retired participants and students were excluded from the analyses.

Analysis of variance (ANOVA), multiple regression analyses (continuous variables) and logistic regression analyses (dichotomous variables) were used to explore possible correlations between social parameters, reported oral hygiene and oral health outcomes after correction for age and gender. A significance level of 0.05 was applied. Regarding missing data, no correction for non-participation or non-response was applied.

To enable a quantitative comparison of the separate effects of putative determinants with their joint effect on oral health outcomes, multivariable regression analyses were performed. The variables which were univariably significant after correction for age and gender up to the 0.1 level were included in a multivariable model. The model was then simplified by removing non-significant terms ($p>0.05$). Age and gender were forced into the model. Results are presented with regression estimates and standard errors or odds ratios with 95% confidence intervals (CI), whichever is appropriate. When an interaction with age is present, results are presented for the quartiles (Q1, median, Q3) of age.

Analyses were performed using SAS version 9.4 without adjustment for multiple testing.

Results

In total, 2,536 households, aiming for a total sample size of 6,750 subjects, were contacted face-to-face or by phone. Written informed consent was obtained from about half of these households (52%), resulting in a total of 3,057 respondents. Lack of interest was the reason for non-participation in 51% of the non-responders. Questionnaire data were obtained from 2,742 participants (89.7%), whereas a clinical oral investigation was conducted on 2,563 subjects (83.8%).

Table 2.2 shows selected characteristics of both the total sample and the subsample of economically active adults. Mean age was 43.3 years (95%CI=[41.2-45.4]) in the total sample and 42.2 years (95%CI=[41.2-43.2]) in the subsample. For both samples, exploration of caries experience resulted in a mean DMFT score of 10.8 (95%CI=[10.0-11.5]) and 11.0 (95%CI=[10.0-12.1]) respectively. The filled teeth (F) component made up the largest part of the score in both groups. On average, almost one tooth per person was affected by untreated decay (D-component). However, decay was clearly not

equally distributed within the population, since only 34.7% of the economically active adults and 28.9% of all subjects had untreated cavities after direct visual inspection.

	Total Sample		Professionally active subsample[1]	
	Absolute numbers	**Weighted proportion (%)**	**Absolute numbers**	**Weighted proportion (%)**
Individuals included	2,563	100%	1,215	100%
Gender distribution				
Female	1,392	53.3%	681	55.8%
Male	1,171	46.7%	534	44.2%
Region				
Flemish region	1,578	58.9%	773	61.6%
Walloon region	848	26.5%	379	25.4%
Brussels-Capital region	137	14.7%	63	13.1%
Increased allowance				
No	2,124	86.6%	1,091	92.1%
Yes	439	13.4%	124	7.9%
Visible plaque accumulation on natural teeth	2,185			
No plaque	821	31.4%	421	30.5%
Plaque on at least one tooth	1,364	68.6%	712	69.5%
Untreated decay	2,559			
Yes	713	28.9%	380	34.7%
No	1,846	71.1%	835	65.3%
Edentulous	2,559			
Yes	309	6.7%	67	2.9%
No	2,250	93.3%	1,148	97.1%
Mean age	**Total Sample**		**Analysis Sample**	
	43.3 (SD=21.7; 95%CI=[41.2-45.4])		42.2 (SD=11.5, 95%CI=[41.2-43.2])	
DMFT **(N=2547)**	**Total Sample**		**Analysis Sample**	
Mean	10.8 (SD=8.7; 95%CI=[10.0-11.5])		11.0 (SD=7.0; 95%CI=[10.0-12.1])	
D	0.8 (SD=1.9; 95%CI=[0.6-1.0])		0.9 (SD=1.9; 95%CI=[0.7-1.2])	
M	4.2 (SD=7.5; 95%CI=[3.5-4.9])		2.9 (SD=5.6; 95%CI=[2.3-3.4])	
F	5.7 (SD=5.6; 95%CI=[5.2-6.2])		7.3 (SD=5.6; 95%CI=[6.4-8.1])	

Table 2.2: Sample characteristics

[1]economically active adults (>18y) with or without a job

Significant differences in untreated tooth decay were observed when considering individuals' highest educational level attained (table 2.3). Subjects with lower secondary diploma presented the most frequently with untreated decay. Unemployed participants and persons with a non-Western nationality had statistically more untreated decay. Besides these social parameters, oral hygiene was related to the prevalence of untreated decay, resulting in higher untreated decay levels when visible plaque accumulation was present and reported frequency of toothbrushing was lower than once a day. These two oral hygiene indicators were linked to each other, confirmed by the finding that people who reported brushing their teeth more than once a day were less likely to present with

plaque accumulation. The proportion of completely edentulous subjects was almost eight times higher in unemployed individuals, compared to those with a job. Regarding educational attainment, the difference in prevalence of edentulousness between subjects without a diploma or with a degree below secondary school level and the higher education group attained a factor 20, and this difference was statistically significant. Belgian subjects presented a lower mean DMFT than persons with foreign nationality or country of birth. Entitlement to a higher reimbursement scale was associated with a lower DMFT score (p=0.04).

The results of the multivariable analyses are reported in tables 2.4 and 2.5. Table 2.4 confirms the significant relation between employment status and presence of untreated tooth decay, but the effect of having a job is predominant in the youngest quartile, with an increased risk of having untreated decay in unemployed young individuals (OR=3.70; 95%CI=[1.30-10.58]). Together with employment, oral hygiene plays a significant role. Reported frequency of toothbrushing and the presence of plaque are both strongly associated with untreated decay, independent of gender and age.

From all explanatory variables considered, edentulousness was mainly associated with employment. However, there seems to be an interaction with gender, resulting in a higher risk for unemployed women to be edentulous, with an odds ratio of 5.32 (95%CI=[1.75-16.12]; p=0.0035).

According to table 2.5, subjects with a higher educational level have lower DMFT than those with low-level or no diploma. An interaction is observed between age and nationality in relation to the DMFT. In the youngest quartile, subjects with Belgian nationality have higher DMFT than people from other Western European countries including USA, Canada and Australia. In contrast, Belgians have lower DMFT than people from other Western countries when the highest age quartile is considered.

	No untreated decay (%D=0)	P	No plaque %	P	Edentulous ness %	p	Mean DMFT (SEM)	p
Employment								
Yes (n=954)	**65.4**	**0.01**	30.5	0.92	**1.4**	**0.01**	10.4 (0.6)	0.10
No (n=261)	**65.1**		30.3		**10.7**		14.5 (1.0)	
Educational level								
Low/No (n=131)	**61.8**	**<0.05**	22.9	0.07	**12.3***	0.18	12.6 (1.0)	0.16
Lower secondary (n=184)	**55.1**		29.0		5.3		13.5 (1.4)	
Higher secondary (n=395)	**63.8**		37.6		2.4		11.6 (0.4)	
Higher education (n=480)	**69.0**		28.3		**0.6***		9.8 (0.8)	
Increased allowance								
Yes (n=124)	64.8	0.77	26.3	0.09	6.3	0.18	**10.2 (1.4)**	**0.04**
No (n=1091)	65.4		30.8		2.6		**11.1 (0.6)**	
Nationality								
Belgian (n=1103)	**66.1**	**<0.001**	30.7	0.7	2.9	0.47	**7.1 (1.2)**	**<0.001**
Other Western country (n=71)	**74.3**		33.1		2.9		**10.0 (0.8)**	
Other (n=33)	**42.3**		23.9		0.3		**11.2 (0.6)**	
Country of birth								
Belgian (n=1037)	**66.4**	**<0.001**	30.9	0.80	3.0	0.25	**7.9 (0.9)**	**<0.001**
Other Western country (n=68)	**73.1**		30.7		3.1		**9.6 (1.0)**	
Other (n=101)	**55.1**		27.1		0.7		**11.5 (0.6)**	
Frequency of toothbrushing								
≤ 1/day (n=103)	**45.7**	**0.02**	**8.8**	**<0.001**	11.4	0.07	14.7 (0.8)	0.26
1/day (n=534)	**67.8**		**32.2**		1.8		10.7 (0.4)	
≥ 2/day (n=567)	**65.9**		**31.5**		2.3		10.7 (0.7)	
Plaque index								
0 (n=421)	**80.0**	**<0.001**					10.4 (0.6)	0.16
>0 (n=712)	**57.2**						10.5 (0.7)	

Table 2.3: Univariate analyses for the economically active population (subsample), after correction for gender and age

*p=0.03 comparing "Higher education" vs "Lower or no diploma"

Outcome variable: UNTREATED DECAY	interaction gender[1]	interaction age[1]	OR	95%CI	P	P overall
Profession/employment	-	**0.022**				**0.049**
Has a job vs no job		25 year	3.70	1.30-10.58	**0.015**	
		45 year	1.24	0.72-2.12	0.43	
		59 year	0.58	0.24-1.37	0.21	
Frequency of toothbrushing	0.078	-				**0.0015**
<1 vs 2 or more	Female	-	6.10	0.89-42.09	0.066	
	Male	-	1.79	0.80-4.00	0.15	
1 vs 2 or more	Female	-	0.83	0.37-1.85	0.64	
	Male	-	1.04	0.52-2.08	0.92	
Plaque index	-	-	2.82	1.85-4.30		**<0.001**
Outcome variable: EDENTULOUSNESS						
Employment	**0.044**	-				**0.013**
unemployed vs employed	Female	-	5.32	1.75-16.12	**0.0035**	
	Male	-	1.10	0.29-4.17	0.89	

Table 2.4: Multivariable regression model of significant parameters affecting the proportion of economically active individuals with untreated decay and the proportion of edentulous subjects.

[1]when p<0.05, the impact of the explanatory variable on the outcome variable is not equal for all subgroups

Outcome variable: DMFT	interaction gender[1]	interaction age[1]	Estimate	Standard Error	P	P overall
Higher education vs low/no diploma	-	-	-3.53	1.16	**0.003**	
Nationality	-	0.0005				**0.003**
Belgium vs other western European countries (incl. USA, Canada, Australia)		25 year.	3.98	1.74	**0.02**	
		45 year.	-0.09	1.36	0.95	
		59 year.	-4.16	1.92	**0.03**	

Table 2.5: Multivariable regression model of significant parameters affecting the DMFT of the economically active population.

[1]when p<0.05, the impact of the explanatory variable on the outcome variable is not equal for all subgroups

Discussion:

The present study describes the caries experience and oral health behaviour of Belgian adults, and aimed to link these oral health outcomes to social parameters.

Mean D_3MFT for the total study population was 10.8 (SD=8.7) and 11.0 (SD=7.0) for the economically active subjects. In 2005, WHO published a map with mean DMFT-scores for all the different regions of the world (Petersen *et al.*, 2005). For the age group 35-44 years, the mean DMFT in Western Europe exceeded 13.9. For the same age group in this sample of the Belgian population, mean DMFT was 10.3 (SD=6.0), which is considerably lower than the figures of Petersen *et al.* However, the data presented by WHO were collected almost 10 years earlier. Furthermore, it is hard to interpret and to compare DMFT scores in adults. DMFT is not only confounded by age, but also by the treatment intentions of dentists. In a cross-sectional design, it is impossible to be sure that all presently filled and missing teeth were preceded by tooth decay. For this reason, the D-component of the score was treated as a different variable to count the real number of decayed teeth at the time of examination.

Untreated decay is a widespread problem in Belgium. Proportions of 28.9% in the total population (>5 years old) and 34.7% in the economically active population call for performant interventions to increase the level of care. The present findings are comparable to those reported by Kassebaum *et al.* (2015). In this systematic review and meta-regression analysis, the prevalence of untreated dental decay in the permanent dentition in 2010 was 35.8% (95%CI=[33.1–39.0]) in Western Europe and 35.4% (95%CI=[33.7–37.3]) globally. It is noticeable that the universal health care insurance coverage in Belgium apparently did not have an impact on these proportions, compared to other countries without this universal coverage. Further research is needed to reveal other existing barriers which declare the high level of untreated decay.

As mentioned in the introduction, Belgian policy measures in oral health care insurance coverage are almost exclusively based on a “threshold value”. Reimbursement for dental fees is not stratified, but dichotomised. When people are entitled to increased allowance for dental treatment, almost all basic dental treatments are completely reimbursed and third-party payment is allowed. In the present study, this was the case for 13.4% of the entire study population and 7.9% of the economically active population. For all other adults, reimbursement is lower and third-party payment is forbidden, without any further differentiation. The authors would suggest more stratification and nuancing in this respect. Governmental initiatives should consider the existing social gradient. Focusing exclusively on the worst subgroup will probably shift the problem towards those who don’t quite meet the inclusion criteria. Preventive actions and policy measures also need a gradient, providing oral health promotion based on the specific needs of every subgroup. This principle is called “proportionate universalism” (Marmot, 2010).

On the other hand, the present results suggest that a purely income-based distinction was not a good predictor to identify high-risk groups for dental caries, since no significant nor relevant differences could be found between participants with an increased allowance and the other subjects. According to the multivariate analyses, the more prominent determinants were employment, educational level and frequency of toothbrushing. The link with employment and educational level is confirmed by a recent systematic review and meta-analysis in which it was observed that 83 surveys had found at least one measure of caries experience to be significantly higher in individuals with a low socio-economic position, while only 3 studies had found the opposite (Schwendicke *et al.*, 2015). This

review also found that the odds of having DMFT/dmft > 0 were significantly higher in those whose educational or occupational background or that of their parent was low (1.21 [1.03–1.41] and 1.48 [1.34– 1.63] respectively). The association between low educational background and having DMFT/dmft > 0 was significantly increased in highly developed countries (1.32 [0.53–2.13]). The huge importance of education and employment in tackling health inequity is also clearly emphasised by Marmot in his influential 'Marmot review'. A common risk approach is indispensable in this context (Marmot, 2010).

Our study confirms the undeniable association between oral health and occupational background. It also provides further detail by exploring age and gender interactions. Employment status was associated with the proportion of subjects with untreated decay but only in the youngest age group: unemployed adults younger than 25 (excluding students) were 3.7 times more likely to have untreated tooth decay than their peers with a job. This higher risk was not present in the older age groups, suggesting that policy interventions should pay special attention to young unemployed adults. Employment was also related to edentulousness, but this correlation was linked to gender differences: unemployed women presented a 5 times higher likelihood of being edentulous than their employed counterparts. The finding that dental caries is more prevalent in women is well-known. Lukacs (2011) summarized the international literature on gender differences in caries experience and reported genetic, hormonal and environmental factors associated with higher dental caries rates in women.

In this study, educational level was the only parameter capable of demonstrating a social gradient, since all other explanatory variables were dichotomised. When educational level is ranked from low to high, absolute figures suggest a decreasing trend in the proportion of edentulousness (12.3%; 5.3%; 2.4%; 0.6%). However, only the difference between the highest educated and the lowest educated subgroups was statistically significant.

Apart from social factors, frequency of toothbrushing was also an important determinant of oral health outcomes. However, Singh *et al.* (2013) observed that oral health behaviour and social status do not only affect oral health separately but rather seem to correlate. Oral health promotion should therefore also pay particular attention to oral hygiene in socially vulnerable groups. Tighter collaborations between oral health workers and organisations in the field of employment and education could be recommended. Oral health promotion can be integrated in school curricula, with higher intensity in schools of lower educational level, according to the principle of proportionate universalism. Accordingly, organisations working with unemployed individuals can be a useful partner in oral health promotion programs. Both strategies need further investigation to confirm a possible positive effect on oral health outcomes and oral health behaviour.

Notwithstanding the strengths of this study, some limitations regarding sampling and data collection must be borne in mind. The National Register, used for sampling, offers the most accurate available representation of the Belgian population. However, its use means that people not appearing in the register (e.g. homeless people and illegal immigrants) could not be included in the survey. Prisoners, residents of religious communities and other institutionalized people (except residents of nursing homes and care centres) were also excluded. Furthermore, the publication reports a high proportion of refusals (48%), mainly due to lack of interest (51%). Apart from the reason of non-participation, further data of non-responders were not available. It is possible that oral health outcomes were

different in responders and non-responders, resulting in bias. During two evaluation meetings with dentist-interviewers (n= 22 and 12) , it became clear that the informed consent procedure was very elaborate and complex. It was raised by the examiners that some participants were even intimidated by the complexity of the consent form. Further research is needed to explore a possible impact on the validity of the results.

Conclusions:

The findings of the survey reported here are that: the proportion of Belgian adults with untreated decay is considerable. Differences in caries experience and untreated tooth decay were not influenced by family income, but oral hygiene, level of education and employment status were the most important determinants. Unemployed young adults have significantly higher levels of untreated cavities and unemployed women are at 5.3 times higher risk of being edentulous.

CHAPTER III

Interventions to reduce oral health inequalities: a review of international literature

LAMBERT M.[1], DE VISSCHERE L.[1], MARTENS L.C.[2], VANOBBERGEN J.[1]

[1] *Department of Community Dentistry and Oral Public Health, Dental School, Ghent University, Belgium*
[2] *Department of Paediatric Dentistry and Special Care, Dental School, Ghent University, Belgium*

This chapter has not been submitted to a scientific journal, but will be submitted in the future.

Abstract:

Objectives: this chapter aims to explore and review existing interventions with a measurable impact on oral health inequalities.

Methods: a search string was structured and built around a PICO framework and entered in PubMed, Easy Web of Science and SUMSearch 2. Both population based studies and studies targeting specific underprivileged groups (P) were included reporting the effects of all kind of interventions (I) on oral health inequalities (O). Articles from the last 10 years were included if they described interventions with a measurable effect on oral health inequalities. The selection procedure was performed individually by two authors.

Results: the search strategy resulted into 1,620 hits. Based on title, 217 original articles were withheld for abstract reading. After independent selection and further discussion on discordant results by the two authors, 32 publications met the inclusion criteria for further full-text reading. During this final step, the majority (n=21) of these full texts were excluded, because they only indirectly suggested effects on oral health inequalities, without statistical evidence. Consequently, 11 publications were included within this review at the end of the selection procedure.

Conclusions: scientific publications describing interventions with a measurable impact on oral health inequalities, are scarce. Both population-based and targeted interventions can contribute to a reduction in inequalities, although they both have limitations. Strategies to tackle oral health inequalities should be based on a multidisciplinary approach and requires support from policy makers and stakeholders.

Introduction:

Socio-economic gradients are widely reported in oral health and oral health behaviour. The pathways to the gradients in oral health, especially in periodontal disease, show similarities to those in general health (Sheiham & Nicolau, 2005). Sabbah *et al*. (2007) showed similar income and education gradients in oral and general health, implying commonalities of the social determinants of both oral and general health.

Some authors expressed their conviction that the common risk factor approach would be capable of reducing social inequalities by focusing on improving general health conditions for the whole population and for specific high-risk groups, and by integrating oral health into general health through a social determinants framework (Do *et al.*, 2014).

Taking into account the Lalonde report (1974) and the rainbow model of Whitehead *et al.* (2001), identifying environmental, biological, lifestyle and policy factors as key determinants of health, it can be expected that social inequalities in oral health should be addressed using a preventive approach based on these determinants.

There is no doubt that the daily use of a fluoridated tooth paste, in combination with a healthy diet, is a very cost-effective way to avoid dental caries (Twetman, 2008). Further, the preventive effect of fluoride varnishes on dental decay in both primary and adult dentition, has been undeniably confirmed by 6 Cochrane systematic reviews from 2003 to 2013, involving 200 trials and more than 80,000 participants (Bonetti & Clarkson, 2016).

When oral health education is the main intervention, the optimal preventive strategy is less clear. As a result of some interventions, an increased knowledge can be observed, but the gain in oral health behaviour is mostly very limited, short-term and unable to prevent new caries lesions and caries progression, because the social environment which drives the populations' behavioural patterns remains untargeted (Ismail *et al.*, 2011; Yevlahova & Satur, 2009). Furthermore, untargeted oral health education programs risk to increase oral health inequalities, as the resourced middle classes with lesser health needs are able to benefit more from the interventions than the more underprivileged individuals (Schou & Wight, 1994). This phenomenon is called the "Matthew effect" (Perc, 2014).

Sogaard *et al.* (1987) demonstrated that the effect of the same educational program might vary in adolescents with different socio-economic background. The authors showed that adolescents from lower social background benefited more from an intervention based on social learning theory, including observational learning, imitation and modelling, while it was sufficient within the children of higher social class to provide a traditional preventive program.

It is clear that providing clinical preventive measures and oral health advice alone will not suffice to reduce oral health inequalities, since they don't involve the underlying social determinants of oral diseases, such as employment, educational level and general living conditions (Watt *et al.*, 2016). To affect these social determinants, multidisciplinary actions are needed, uniting all relevant actors in science, health care, politics and the public (Watt *et al.*, 2015). The Ottawa Charter stated that building healthy public policies, creating supportive environments, strengthening community action,

developing personal skills and reorienting oral health services, are cornerstones to improve oral health (WHO, 1986).

It remains challenging in oral health interventions to efficiently reach all members of society, considering the social gradient in oral health (Lòpez *et al.,* 2006; Sanders *et al*., 2006). The existence of a social gradient implies that the most advantaged members of the society have better oral health outcomes than the less privileged, but not that all oral diseases are concentrated in one subgroup. Indeed, there is no dichotomous 'social threshold', dividing the population into a group needing all oral health promotion and a healthy group which does not need oral health promotion at all. Population-based interventions are insufficient to reach high risk groups and might widen the social gap, but focusing only on high-risk groups denies the preventive needs of the rest of the population. This is why preventive actions also need a 'gradient', providing oral health promotion with the scale and intensity proportionate to the level of disadvantage. Marmot (2010) calls this approach "**proportionate universalism**". Carey *et al.* (2015) set up a framework for the application of proportionate universalism in general health. This framework requires the incorporation of elements of both general and specific universalism, including sanitation for all and other universal protections for citizens, such as safe water, education, employment, etc. Accordingly, public health and oral health interventions should be part of broader policy and community strategies, in order to efficiently reach all social strata within the population.

In oral health research however, proportionate universalism is not well-incorporated. A search on PubMed database results in one single hit when entering "Oral health AND proportionate universalism" as search string, without using MeSH terms (Matsuyama *et al.*, 2016).

Research in the field of oral health inequalities mainly focusses on changing oral health behaviour and disease management in specific high-risk groups, without taking into account the underlying determinants and without investigating a measurable effect on oral health inequalities within the global population. For this reason, the present study aims to explore and review existing publications from the last 10 years, reporting effects from interventions of all kind on oral health inequalities as a measurable outcome.

Methods:

The search strategy was structured and built around a PICO framework. Starting with the P, both population based studies and studies targeting specific underprivileged groups were included reporting the effect of all kind of interventions (I) on oral health inequalities (O). All relevant key words were combined into following search string:

((vulnerable populations) OR public assistance) OR socio-economic factors) OR sociological factor) OR poverty) OR social class) OR poverty areas) OR social marginalization) OR social discrimination) OR social segregation) OR psychosocial deprivation) OR cultural diversity) OR ethnic groups) OR underprivileged) OR impoverished)) AND ((health education) OR health promotion) OR prevention) OR health literacy) OR support groups) OR social network) OR social gathering) OR health changes) OR intervention) OR interventions) OR health communication) OR campaign) OR campaigns) OR health advocacy) OR health programme) OR community advocacy) OR health program) OR social campaign)

OR social support) OR social campaigns) OR social care) OR health coaching) OR social intervention) OR environmental change strategies) OR screening) OR preventive) OR prophylaxis) OR healthy environment) OR community mobilization) OR habits) OR behaviour modification) OR prophylaxis screening) OR primary prevention) OR health screening) OR proportionate universalism)) AND ((effectiveness) OR efficacy) OR efficiency) OR impact) OR evidence) OR outcomes)) AND ((oral health inequalities) OR oral health) OR dental health) OR oral hygiene) OR oral).

The search string was entered in PubMed, Easy Web of Science and SUMSearch 2. In general, reviews and original studies were included when published between January 2008 and November 1, 2017, without language restrictions. For PubMed, the search strategy was refined using 'review', 'clinical trial' and 'published in the last 10 years' as filters. Since SUMSearch 2 makes use of PubMed for its search method, the same filters could be used. In Web of Science database, publications from 2008 to 2017 were included after selecting for articles and reviews.

Concerning the content of the publications, there was only one inclusion criterion: articles were included if they described interventions with a measurable effect on oral health inequalities. These interventions could be of any kind, targeting underprivileged individuals of all ages, intermediary workers, dental professionals, policy makers or the whole population.

All titles referring to oral health inequalities or interventions in underprivileged groups were screened on title by one author. After this, two independent authors (ML and LDV) individually performed the abstract selection, including all abstracts reporting effects on oral health inequalities, without further specification. Abstracts which were scored inconsistently by the two examiners, were listed and further discussed until consensus was reached. Next, full texts were carefully considered by the same two authors, in order to include only those publications reporting quantitative results of the effects on oral health inequalities.

Results

The described search strategy resulted into 614 hits on PubMed, whether Web of Science and SUMSearch 2 provided 876 and 130 citations respectively. Based on title, 217 original articles were selected for abstract reading. After independent selection and further discussion on discordant results by the two authors, 32 publications met the inclusion criteria for further full-text reading. During this final step, the majority (n=21) of these full texts were excluded, because they only indirectly suggested effects on oral health inequalities, without specifying these suggestions by performing statistical analyses. Consequently, 11 publications were included within this review at the end of the selection procedure. Figure 3.1 describes the flowchart of the literature review and table 3.1 summarizes the included articles.

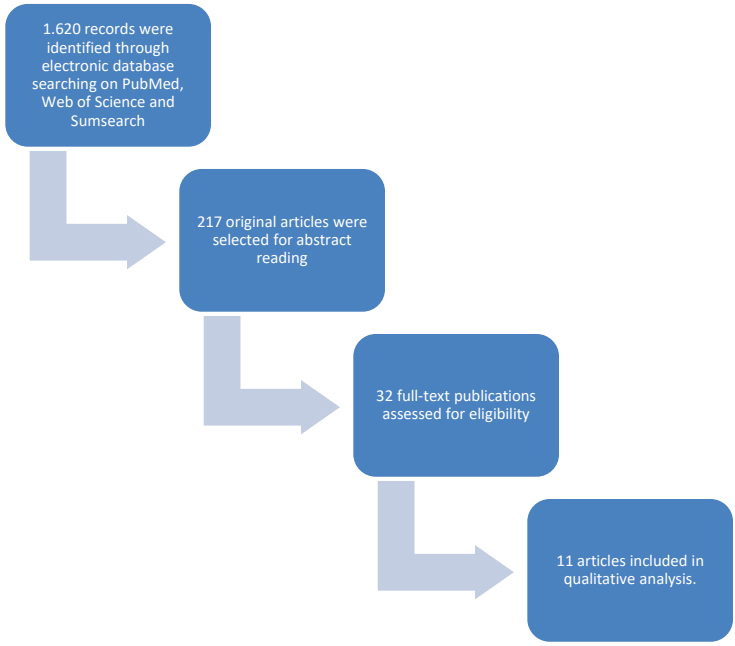

Fig. 3.1: flow chart of the literature review

Author	Year	Study design	LoE*	Country	Intervention	Oral health outcome
Achembong *et al.*	2014	Observational study	III	USA	Medicaid preventive dentistry program in primary care medical offices (Into the Mouth of Babes Program)	DMFT
Celeste & Nadanovsky	2010	Observational study	III	Brazil	Public policy	Missing and decayed teeth
Costa *et al.*	2013	Observational study	III	Brazil	Water fluoridation; Public policy	Access to care, DMFT
Kim *et al.*	2017	Observational study	III	South-Korea	Water fluoridation	DMFT
Lewis *et al.*	2009	Observational study	III	USA	Access to the Baby and Childhood Dentistry (ABCD) program	Preventive dental visits
Matsuyama *et al.*	2016	Observational study	III	Japan	school-based fluoride mouth rinse program	DMFT
McLaren *et al.*	2016	Observational study	III	Canada	Water fluoridation	DMFT
Nasseh & Vujicic	2013	Observational study	III	USA	Policy measure: expanded dental benefits to all low-income adults between 19–64	Oral health care utilisation
Plutzer *et al.*	2011	RCT	II	Australia	Anticipatory guidance for pregnant women to prevent ECC	ECC prevalence
Raittio *et al.*	2015	Observational study	III	Finland	Dental subsidization reform	OHRQoL
Saleh *et al.*	2012	Observational study	III	Malaysia	Mass Media Approach to prevent oral cancer	Knowledge scores

Table 3.1: list of included publications after completing the review process.

* Level of Evidence, according to Oxford Centre for Evidence-based Medicine – Levels of Evidence (2009); www.cebm.net

Of the 11 included publications , 2 articles were Brazilian, 3 American, 1 South-Korean, 1 Japanese, 1 Canadian, 1 Australian, 1 Finish and 1 Malaysian. Regarding language, all articles were written in English, except one, which was published in Portuguese (Costa *et al.*, 2013). Regarding study design, the included publications consisted of 10 observational studies and 1 RCT. According to table 3.1, seven publications used dental caries as oral health outcome variable, three reported on access to oral health care and resources, one on knowledge and one measured oral health-related quality of life (OHRQoL).

Plutzer *et al.* (2011) performed a randomised controlled trial within 649 Australian young women, measuring the impact of **anticipatory guidance** on the prevention of Early Childhood Caries (ECC) within single- and two-parent families. The intervention, which was applied during pregnancy and at the age of 6 and 12 months, reduced the frequency of ECC from 8.1% to 1.1% in two-parent families and from 16.3% to 4.5% in single-parent families. The anticipatory guidance had an undeniable positive impact on both groups, although its impact on social inequalities is ambiguous. Regarding absolute risk reduction, the number of prevented ECC cases was higher in children from single-parent families. However, when relative risk reduction is considered, the intervention reduced the ECC experience with a factor of 3.5 in single-parent families, compared to a sevenfold reduction in children from two-parent families. Accordingly, the intervention seemed to have a relatively higher impact on the more privileged families, although absolute figures would suggest the opposite.

Three publications (Costa *et al.*, 2013; Kim *et al.,* 2017; McLaren *et al.*, 2016) described the effects of **water fluoridation**, one of the oldest governmental interventions aiming to reach the entire population, including its most vulnerable members. The present literature search provided additional evidence supporting water fluoridation, even in areas where fluoridated toothpaste is largely available. A recent survey in South-Korea showed that water fluoridation was effective to reduce DMFT scores in primary school children (Kim *et al.*, 2017). Furthermore, the authors could demonstrate that social disparities were absent or less pronounced among children living in a fluoridated water area, compared to peers from a comparable area without water fluoridation. Another survey was very complementary to these results, by inverting the research hypothesis, exploring the possible deterioration in oral health inequalities after cessation of water fluoridation in Canada (McLaren *et al.*, 2016). The authors observed increased disparities in caries experience after stopping the fluoridated water program.

Two Brazilian ecological surveys explored the effects of the Brazilian **public policy** on oral health inequalities (Celeste & Nadanovsky, 2010; Costa *et al.*, 2013). Celeste and Nadanovsky (2010) investigated the impact of Brazilian public policy measures on oral health and oral health inequalities, excluding water fluoridation. A Scale of Municipal Public Policies (SMPP) was developed, including education, child's welfare, sanitation and infrastructure, and public dental services. In a multivariate model, the authors found that the effects of these public policy measures varied according to socio-economic status. They observed a stronger effect on people with higher income and educational level, and on individuals with one or more cars. As an example, an increase of one unit on the SMPP scale was associated with a decrease of 26% in the number of decayed teeth among the individuals with less than basic education, whereas the same increase of one unit led to 38% fewer decayed teeth among those with a degree of higher education. Furthermore, the authors could demonstrate that the association between income inequality and oral health was mostly explained by the public policy variable. It seemed that the more affluent part of the population benefited more from population based public policies than the more underprivileged subgroups in society. These findings were confirmed by Costa *et al.* (2013), comparing different cross-sectional surveys in 1986, 2003 and 2010 to explore a possible reduction in oral diseases, facilitated by the use of fluoridated water and the introduction of public health policy interventions. Despite the policy measures, inter-regional disparities between the poor North and the rich South-east region increased over the survey period, resulting in increased social inequalities in DMFT and access to oral health care.

Three surveys originated from the United States. Firstly, Achembong *et al.* (2014) described the "**Into the Mouths of Babes Program**" (IMBP), a Medicaid program in North Carolina in which non-dental medical professionals were paid for up to 6 medical visits in which preventive oral care was provided to poor children up to 3.5 years of age, including risk assessment, fluoride varnish application and parental oral health counselling. The authors could analyse almost 1 million records over a period from 1998 to 2010. They found that IMBP had a better effect in schools with more than 80% children being involved in the National School Lunch Program (a valid measure of poverty), compared to the effect in all schools together. An increase by one unit in the average number of IMBP visits per child aged 0 to 4 was associated with a decrease of 0.32 (95%CI=[-0.55;--0.09]) in the school dmft level, whether in all schools, this decrease was 0.25 (95%CI=[-0.40;-0.09]. Although the non-controlled design of the survey, the IMBP must be contributing to a reduction of inequalities in dental caries among preschool children.

Secondly, the state of Washington developed the "**Access to the Baby and Childhood Dentistry**" (ABCD) program (Lewis *et al.*, 2003). This program targeted Medicaid-insured children of 6 years of age to improve their access to preventive dental care, by providing outreach, referral to a participating dentist in the ABCD program, family education and case management. Furthermore, participating dentists received a financial incentive and underwent training to increase their abilities and comfort with treating young children. The results of this observational study showed that 45% of the 6 year-old children living in established ABCD-counties had at least one preventive dental visit (PDV) in 2003, compared to 36% in non-ABCD counties. The proportion of 45% was also statistically significantly different from the overall US figures ($p<0.001$). According to national statistics, 26% of all American children had a PDV in 2003. These national figures showed strong inequalities between privately insured children (37%) and Medicaid children (23%). Since the 45% proportion within the ABCD-counties was much higher than all other groups and the ABCD-program was only implemented in low-income children, the authors concluded that the ABCD-program was strongly effective in reducing social inequalities in oral health.

A third American survey, Nasseh and Vujicic (2013) described the effects of a **health reform** in Massachusetts in 2006, expanding dental coverage to all adults between 19 and 64 whose annual income was at or below 100 percent of the federal poverty line. Over a six-year period between 2003 and 2009, dental care use in Massachusetts non-elderly adults increased with 2.9%, compared to eight control states. This increase could be attributed to effects in the poor, showing an 11% increase in oral health care utilisation, while there was no effect in the non-poor.

The theme of a subsidisation reform was also treated by Raittio *et al.* (2015), using inequalities in oral health-related quality of life (OHRQoL) in Finish adults as outcome variable, before and after abolishing age restrictions on subsidised dental care in 2001. Since this reform, the entire Finnish population was entitled to use primary dental services and also received reimbursement for private dental treatment costs. Although the authors cited other publications demonstrating at least a temporal reduction of inequalities in oral health care utilisation, their own research could not provide evidence to assume that the reform had a beneficial effect on inequalities in OHRQoL.

Matsuyama *et al.* (2016) investigated the impact of a nationwide **school-based fluoride mouth rinse program** in Japanese children, collecting data on DMFT from multi-year birth cohorts between 2001 and 2007. The study showed that each 1% increase in utilisation of the program was significantly

associated with 0.011 lower DMFT scores for 12-year-olds. Regarding inequalities, it was found that the fluoride mouth rinse program had a higher impact on DMFT-scores at the age of 12 for those regions having high prevalence of dental caries in 3 year-olds, showing that the program reduces inequalities in dental caries between Japanese prefectures.

Finally, Saleh *et al*. (2012) reported on the effects of a **mass media campaign** in Malaysia, aiming to promote awareness and early detection of oral cancer. The campaign consisted of a 20-second television spot which was aired 2-3 times a day, for 32 consecutive days. Awareness was measured by the number of respondents having heard of oral cancer and by those being able to recognise its symptoms, by using a questionnaire sent by e-mail. The mass media campaign tended to increase social inequalities between groups with different educational levels, since only respondents with a university degree had significantly better scores in recognising the symptoms after the campaign. Furthermore, the Indian ethnic minority group received the least exposure to the campaign, although this subgroup had the highest incidence of oral cancer in Malaysia.

Discussion

From the literature survey, it became clear that very few studies included oral health inequalities as a measurable outcome, leading to only 11 studies from the last decade meeting the inclusion criteria. According to the Oxford Centre of Evidence Based Medicine, none of them obtained a level 1 of evidence. All publications were observational studies, except one RCT (Plutzer *et al.*, 2011). However, the follow up rate of <80% in this study resulted in a level 2 of evidence. The lack of high-quality research on this item is alarming. It is important to monitor the impact of interventions on oral health inequalities, since even interventions designed to reduce inequalities can have the opposite effect (Celeste & Nadanovsky, 2010; Costa *et al.*, 2013). Because of the low level of evidence, none of the selected studies can be considered as universally applicable. Nevertheless, they contain important elements to be discussed in this section.

Three surveys were in favour of water fluoridation which reduces oral health inequalities if every region has equal access to it. This confirms earlier findings of Riley *et al.* (1999), showing that water fluoridation had a more beneficial impact on children experiencing high material deprivation, resulting in a reduction of inequalities in dental caries. The statement that fluoridated water does not have an added value in modern countries with large access to fluoridated toothpaste, is countered by the surveys of Kim *et al* (2017) and McLaren *et al.* (2016), describing the positive effects of water fluoridation on reducing oral health inequalities in South-Korea and the negative impact of stopping this measure in Canada. A possible explanation could be found in the fact that, until present, underprivileged groups still have less access to efficient fluoride toothpastes and report worse oral health behaviours. However, the authors of the Canadian survey call for additional studies to control for potential confounding variables and to collect better data on the individual socio-economic status of participants.

The beneficial effects of both water fluoridation and the fluoridated mouth rinse program in schools (Matsuyama *et al*., 2016) lead to the interesting finding that one single intervention for the entire population (**population-based approach**) only reduces the social gap between subgroups when it is applied automatically and mandatory to all. On the contrary, when information or resources are

offered within the population without obligation, oral health inequalities are widened, according to the "Matthew effect". These findings might lead to the conclusion that a population-based intervention can only reduce oral health inequalities when it excludes every individual freedom.

Despite their beneficial effects on oral health outcomes and inequalities, it is questionable if top-down decision making might lead to active behaviour change, since the effective components of behaviour change include goal setting, action planning and self-monitoring (Asimakopolou & Newton, 2015). Self-efficacy, the belief in the own ability to change behaviour, showed to be a strong predictor of success in behaviour change, suggesting that interventions should focus on enhancing self-efficacy beliefs (Bandura, 1977). This is not the case when interventions are automatically applied to all.

In modern democratic societies, individual freedom of choice and self-determination are of fundamental importance. Policy measures such as fluoridated water would be largely contested in western countries by ethical committees, since every citizen should have the individual right to choose between fluoridated and non-fluoridated water, based on an informed consent. A generalised view on the present literature review should suggest that oral health inequalities are based on a purely individual choice to accept or refuse health promoting interventions. This conclusion would make the individual fully responsible for his oral health as a consequence of his behaviour. However, Sabbah *et al*. (2009) found that socio-economic disparities could not be eliminated after adjusting for health behaviour. This suggests that oral health inequalities cannot be linked exclusively to compromising behaviour of the underprivileged groups. Furthermore, many researchers demonstrated that health outcomes are negatively affected by various environmental factors, such as health literacy (Berkman *et al.*, 2011), origin (Riggs *et al.*, 2014), poverty (da Fonseca, 2012) and many parental factors (Hooley *et al.*, 2012; Duijster *et al.,* 2013 Kumar *et al.*, 2016). These determinants cannot be attributed to any form of individual choice. For this reason, governmental initiatives aiming to create supportive environments to improve oral health, should always seek an ethical balance between legislation acting against the individual freedom of citizens, and the delegation of the oral health management to the individual (self-empowerment). Moreover, accountability should always be accompanied by empowerment.

Apart from the population approach, the present review also provided three articles describing interventions exclusively targeting underprivileged groups (**high-risk approach**). Both the ABCD-program and the IMBP showed reduced social disparities between Medicaid children and their more fortunate counterparts (Lewis *et al*., 2009; Achembong *et al*., 2014). Similar results were found for the expanded dental benefits to all low-income adults between 19–64 in Massachusetts (Nasseh & Vujicic, 2013). Despite these positive effects, the authors of the latter survey regret the abolishment of oral health benefits in several other states: Missouri and Washington eliminated all adult dental Medicaid benefits, and California went from full dental Medicaid coverage to no coverage in July 2009. The authors referred to other publications, showing that the percentage of adult Californian Medicaid beneficiaries receiving dental services, dropped from 35% to 12% in one year since the reform. (Maiuro, 2011). These findings prove the importance of policy interventions and political priorities on both the oral health of vulnerable subgroups and oral health inequalities.

Within the ABCD program, paediatricians and family physicians were an important source of referral, confirming the importance of a **multidisciplinary approach**, including professional workers and policy

makers to tackle structural determinants (WHO, 2008). Furthermore, special emphasis was put on case management. To tackle inequalities, increasing interest is going to the effects of case managers. Some interesting randomised controlled trials were set up within Australian aboriginals and Maaori people in New Zealand (Blinkhorn *et al.*, 2012; Broughton *et al.*, 2013). Furthermore, Cunha-Cruz *et al.* (2015) proposed a Population-centred Risk- and Evidence-based Dental Interprofessional Care Team (PREDICT), working with 'case managers' to refer children who need dental services. Unfortunately, these protocols could not yet provide statistical results.

Although '**proportionate universalism**' is a new interesting concept in oral health promoting interventions introduced in 2010, it was only mentioned by one of the included articles (Matsuyama *et al.*, 2016). Moreover, none of the 11 included articles fully corresponded to the principles of proportionate universalism, since they all were lacking a gradual approach.

Eight of the included articles described a population-based approach. In this approach, the existence of different social subgroups was considered, but only one single intervention was applied for all of these subgroups. On the other hand, the high-risk approaches (n=3) dichotomised the population into a high-risk group and the rest of the population, after which only the high-risk group was included for intervention. This dichotomisation is in contradiction with the step-wise deterioration of oral health over social subgroups and the preventive need of all of these subgroups (Marmot, 2010). Further research integrating 'proportionate universalism' in oral public health is recommended.

Conclusion

Scientific publications describing interventions with a measurable impact on oral health inequalities, are scarce, especially when proportionate universalism is considered. Both population-based and targeted interventions can contribute to a reduction in inequalities, although they both have limitations. Strategies to tackle oral health inequalities should be based on a multidisciplinary approach and requires support from policy makers and stakeholders.

CHAPTER IV

The impact of a nationwide oral health promotion program on oral health and oral health inequalities: A prospective 4-year longitudinal intervention study in primary school children in Flanders-Belgium.

LAMBERT M.[1], DE VISSCHERE L[1], MARTENS LC.[2], DESCHEPPER E[3], VANOBBERGEN J.[1].

[1] *Department of Community Dentistry and Oral Public Health, Dental School, Ghent University, Belgium*
[2] *Dept Paediatric Dentistry and Special Care, Dental School, Ghent University, Belgium*
[3] *Biostatistics Unit, University Hospital Ghent, Ghent University, Belgium*

This chapter is an edited version of the manuscript, which was submitted for review in ***Community Dental Health***

Abstract

Objectives: the present study investigated the impact of a 4-year longitudinal oral health promotion program (Glimlachen.be®) on oral health, oral health-related knowledge and oral health inequalities in primary schoolchildren.

Methods: the study was executed between 2010 and 2014, within a random sample of Belgian primary school children (born in 2002), which was compared with two cross-sectional control groups before and after the survey. The intervention consisted of an oral health educational program, implemented yearly and supported with online tools, and evaluated through an annual oral health examination. Data were collected in a mobile dental unit, using DMFT, number of decayed teeth, Restorative Index, Treatment Index, Care Index and plaque index (Sillness & Löe) as outcome variables. Knowledge was tested by means of a validated questionnaire. Being entitled to a corrective policy measure (Maximum Bill) was used as an explanatory variable, dichotomising the sample into a higher and lower social group. Mixed model analyses were conducted to evaluate changes over time between intervention and control group and between higher and lower social subgroups. Univariate tests were executed to analyse differences at both T_0 and T_4.

Results: 1,058 subjects (23.8%) could be surveyed over the entire 4-year longitudinal period, of which 116 were eligible for the Maximum Bill system. Mixed model analyses revealed that the intervention had a significant impact on the number of decayed teeth ($p=0.009$) and knowledge scores ($p<0.001$), in favour of the intervention group. There was no statistical evidence to assume that the 4-year intervention had a different effect on the two social groups. Socio-economic inequalities were present both at T_0 and T_4.

Conclusion: the oral health promotion program had a sustainable impact on oral health knowledge and the number of decayed teeth in primary school children. No impact on oral health inequalities could be demonstrated. However, the high drop-out rate, especially in children with the lowest social status, must be taken into consideration.

Introduction

Health promotion interventions at school can play an important role in nearly all children during the most influential stages of their lives. Health promotion in general and oral health education in particular might be indispensable topics in the school curriculum, since deprived oral health remains a major health problem, starting from childhood. In 2010, untreated tooth decay in primary teeth was ranked at place 10 when listing the most prevalent diseases in the world (Marcenes *et al.*, 2013). Besides a high prevalence of oral health problems among children, inequalities are present, resulting in a gradient in oral disease levels, in particular caries levels, between the least and most developed communities. (Do, 2012).

Deprived oral health can have a negative impact on the quality of life (Martins *et al.,* 2017). Children with poor oral health are almost 3 times more likely to miss days from school as a result of toothache, and this directly affects school performance (Jackson *et al*., 2011; Seirawan *et al.*, 2012). Furthermore, parents miss on average 2.5 days per year from work or school because of their children's oral health problems (Seirawan *et al.*, 2012). Oral diseases at young age can have a substantial long-term impact on people's life, but at the same time, early life conditions such as childhood financial hardship, might compromise oral health in later adulthood (Listl *et al*., 2014[b]). Since most oral diseases are both preventable and reversible at early onset, there is need to develop successful methods to tackle both oral diseases and oral health inequalities. Regarding the existent gradient, focusing solely on the most disadvantaged will not reduce the health gradient, only tackling a small part of the problem (Pitts *et al.*, 2011).

In Belgium, the government invested in (oral) health care by introducing the universal health care insurance coverage in the 1960's, aiming to reduce the barriers to access for (oral) health care for all layers of the population. Many oral health care services are covered for 75-80% by a compulsory health care insurance. For children up to 18 years and vulnerable individuals, a full reimbursement of the standard care package is guaranteed, provided that the dentist acceded to the convention between the national health insurance agency and dental professional organisations. However, it is possible that even if access to care is facilitated, care is not equally demanded by all social groups. Despite all current measures, clear oral health disparities remain present between social subgroups of all ages in Belgium (Vanobbergen *et al.*, 2001; Willems *et al.,* 2005; Vanobbergen *et al.*, 2010; Lambert *et al*., 2017).

A specific setting to reach almost all children from different social backgrounds, is the school environment. The World Health Organisation (WHO) already took steps to involve schools in health promotion, through the 'Health Promoting School' project, in which oral health can be easily integrated (Kwan *et al*., 2005). Children, but also their parents and teachers, can be provided with skills enabling them to make healthy choices and to adopt a healthy lifestyle. Moreover, these behaviours might be more sustainable when developed at young age.

The Glimlachen.be® project (Glimlachen.be, 2014) aimed to help Belgian school children and their parents to establish good oral health habits to prevent oral diseases. This nationwide oral health promotion program started in 2009 and was targeted at children and adolescents aged between 0 and 18. The program provided and supported schools with educational materials to integrate oral health promotion activities. This project was conducted by the Flemish Dental Association (VVT) under the authority of the National Institute for Health and Disability Insurance (NIHDI).

The present study followed a random sample of Flemish school children, born in 2002. It aimed to evaluate the impact of the 4-year longitudinal oral health promotion program on firstly, oral health and oral health-related knowledge of these primary schoolchildren and secondly, on reducing inequalities in child oral health outcomes.

Methods

The study applied a longitudinal cohort design over a period of 4 years with an external cross-sectional control group.

Population and sampling procedure

Data available from the Glimlachen.be® project were used, collected between 2010 and 2014 from a representative sample of primary school children (born in 2002) who were examined yearly (between 8 and 11 years of age). These subjects were compared to a randomly selected cross-sectional control group at the beginning and at the end of the survey.

To be involved in the oral health promotion program, schools were randomly selected, based on a stratified sampling procedure at school-level. Strata were obtained by combining the five Flemish provinces with the three types of educational system (public, municipal and private schools), striving for an equal spread in capacity of the schools. From all 2,340 primary schools in Flanders, a random sample of 335 schools was extracted, with an oversampling of 2% for schools with assistance from special education for disabled children or children with learning or educational difficulties. Subsequently, these 335 schools were randomly divided into an intervention group (n=305) and control group (n=30).

At onset (2010), all 8-year-old old children, attending the third grade of the selected intervention schools, participated in an oral health screening program, in which a clinical oral examination was carried out in the school setting. This cohort was examined every year up to the age of twelve (2014) and compared to cross-sectional control groups, drawn from the total population excluding the intervention schools.

The sample size was based on practical feasibility, such as the availability of three mobile dental units and the number of school days in one year.

Intervention

The intervention consisted of an oral health educational program. All educational material and programs were developed over a four-year period, with a special field of interest for every year. During the first year, four games were developed to introduce oral health in a playful manner. In the second year, oral hygiene was focused on , whether in the third and fourth year emphasis was put on healthy nutrition and dental attendance respectively. A special website, logo and gadgets were developed and implemented. The educational program was implemented every year, together with a yearly oral health examination. The information was taught by a professional dental assistant in an interactive

way. Besides this yearly intervention, all materials, games and methods were available for teachers via the website.

Data Collection

Data were collected by means of an oral health examination survey and a self-administered questionnaire. These data were supplemented with additional data of the Belgian Inter-mutualistic Agency (IMA) national database on utilisation of (oral) health care services, in order to collect reliable information on participants' insurance status, socio-economic position and utilisation of oral health care services.

Oral health condition was recorded yearly in both intervention and control group, by direct visual inspection in a mobile dental unit in school premises by 44 trained and calibrated dentist-examiners. Calibration was undertaken to avoid information bias, using a series of full-mouth photographs in PowerPoint slides simulating the clinical situation of patients. Dental caries diagnosis calibration resulted in an Intra Class Correlation Coefficient (ICC) for all examiners of 0.86 (95%CI=[0.82-0.90]). General kappa score was 0.72. All examiners were blinded for the children's social status.

The examiners registered several oral health-related parameters. Caries detection was based on the International Caries Detection and Assessment System (ICDAS), using six subcategories of decay, ranging from 1 (first visible change in enamel) to 6 (extensive cavity with visible dentin possibly reaching the pulp). DMFT/dmft was used to count the number of decayed (D), missing (M) and filled (F) teeth (Klein *et al*. 1938). Both caries at D_1 level (ICDAS > 0) and D_3 level (ICDAS ≥4) were taken into account. The D-component (at white spot (D_1) level) was regarded as a separate variable to count the number of teeth with caries activity. Further, oral care level was calculated by means of the Restorative Index (RI= (F/(D_3+F)) *100), Care Index (CI= (F/(D_3+M+F))*100) and Treatment Index (TI= ((M+F)/(D_3+M+F))*100), all ranging from 0 to 100%. All three indices were dichotomised to divide subjects into two groups: children without untreated caries (RI=100%, CI=100%, TI=100%) and children with untreated caries (RI<100%, CI<100%, TI<100%).

Dental plaque accumulation was scored using the Plaque Index of Sillness and Löe (1964). This index calculates the mean buccal surface plaque score of six reference teeth on a scale from 0 (no plaque) to 3 (visible plaque on more than one third of the buccal surface).

Knowledge was measured by means of a validated questionnaire, answered by the children. A higher score out of 10 correlates to more knowledge. An expert panel tested the content validity of the items, after which the reliability of the questionnaire was pretested in a small convenience sample of 25 primary school children on two time points (test-retest). In order to estimate reliability, the Cronbach's Alpha was calculated, resulting in a score of 0.75, which fits into the required interval of 0.70<Cronbach's Alpha<0.90.

Covariates

In order to explore the possible impact of the intervention on reducing oral health inequalities, a summary measure was used to characterize the low-income children. The "Maximum Bill" is a mechanism which calculates a cost limit for medical care for every individual, based on income levels.

The higher the family income, the higher the cost limit. When total medical costs on yearly base exceed this limit, they will be entirely and automatically reimbursed. Accordingly, those who benefit from this measure correspond to social high-risk groups, whether those without can be considered as more fortunate. In this survey, children were considered as underprivileged when they received a Maximum Bill intervention for at least one year between 2009 and 2013 on an individual basis. These data could be collected by consulting the Inter-mutualistic Agency national database, a procedure which was supervised by the national privacy commission.

Data analysis

Data analysis was carried out in the IBM SPSS Statistics V24.0 (SPSS Inc., Chicago, IL, USA). After explorative data analyses, linear mixed model analyses (continuous variables) and generalised mixed model analyses (dichotomous variables) were conducted to evaluate changes over time. A "time by intervention" interaction term was included in the models to evaluate differences in time evolution between the intervention and the control group. Only those children who received the oral health promotion and oral examination every single year during the whole 4-year study period were included for data analysis, in order to examine the impact of the entire oral health program. Univariate tests were executed to analyse differences between intervention and control group at T_0 and T_4.

Next, the influence of social status (being entitled to the Maximum Bill for at least one year between 2009 and 2013) was assessed using a "Maximum Bill by time" interaction term. To explore the effects of the intervention depending on children's social class, only the intervention group was included for this analysis.

Univariate comparisons between children eligible for the Maximum Bill and the others, within the intervention group, were executed to explore and quantify possible oral health inequalities at both T_0 and T_4.

For all analyses, alpha was set at < 0.05.

Ethical aspects

All procedures performed in the present study were in accordance with the ethical standards of the institutional and/or national research committee (EC University hospital Ghent, No. B67020108008) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All parents gave written informed consent prior to data collection. All schools received information about the study protocol and agreed to participate. Children requiring dental treatment or periodic recall were referred to the dentist.

Results

Not all selected schools approved to take part in the survey, resulting in a 74% response rate, involving 247 schools. Data of non-responding schools were not collected. The intervention group consisted of

195 primary schools for normal primary education (NPE) and 26 schools for special primary education (SPE), whether the control group included 22 normal and 4 special lower education schools. Figure 4.1 compares the original sample selection to the responding schools.

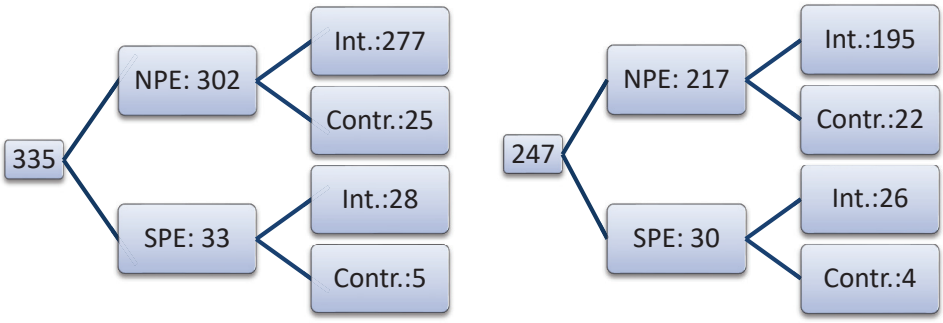

Fig. 4.1: Distribution of primary schools for normal primary education (NPE) and schools of special primary education (SPE) in the original sample selection (left) and the responding schools (right), and in intervention (int.) and control group (contr.)

From the initial sample of 6,533 8-year-old primary school children in the intervention group at baseline (T_0), 4,663 children could be linked at the IMA database to determine their social status. Incomplete information on the national registration number could explain the loss of 1,870 children. From the remaining 4,663 children, 213 did not have a registered insurance status, resulting in a further 4.6% drop out. In those of whom insurance was conforming to legislation, 950 children (21.3%) benefited from the Maximum Bill system. At the end of the study (T_4), 1,058 subjects (23.8%) could be surveyed over the entire longitudinal period of 4 years, of which 116 (11.0%) were eligible for the Maximum Bill system. The main reasons for dropouts were school absence during at least one of the annual oral health examinations, due to sickness or other reasons, moving away, school failure or having to repeat school years, parent and child refusals. The present results section only analysed those who received all four oral health examinations.

At baseline (T_0), mean age was 8.3 in both intervention and control group (SD=0.55 and 0.56 respectively). At T_4, the mean age of intervention and control group was 11.3 (SD=0.56) and 10.7 (SD=0.63) respectively.

Results of analyses of the continuous outcome variables are presented in table 4.1. At onset, there were no significant baseline differences in mean Plaque Index (PI) between intervention and control group. Both groups showed significantly decreasing PI over time ($p<0.001$), but only at T_4 the differences between intervention and control reached statistical significance. In the multivariate analysis, a borderline statistical difference over time in PI between the intervention and control group could be found (interaction term "time by group"; $p=0.053$). For the number of decayed teeth, mixed model analysis revealed a significantly different evolution over time between control and intervention group ($p=0.009$).

Regarding knowledge, baseline scores were significantly higher in the intervention group, compared to the controls. During the observational period, significant differences in the evolution over time could be observed. No statistical differences were observed in the control group after four years, whether a significant increase in knowledge was detected in the intervention group (p<0.001).

Year	Group	Mean PI	95%CI	P-value
T_0	Intervention	0.71	[0.68; 0.75]	
	Control	0.76	[0.70; 0.81]	p=0.18
T_4	Intervention	0.39	[0.36; 0.43]	
	Control	0.53	[0.47; 0.60]	**p<0.001**
p-value for evolution over time per group (interaction term time*group)				**p=0.053**
Group	**Difference T_0-T_4**	**Mean Difference**	**95%CI**	**P-value**
Intervention	T_4-T_0	-0.32	[-0.36; -0.28]	**p<0.001**
Control	T_4-T_0	-0.23	[-0.31; -0.14]	**p<0.001**
Mean knowledge				
Year	**Group**		**95%CI**	**P-value**
T_0	Intervention	6.1	[6.0; 6.2]	
	Control	5.7	[5.5; 6.0]	**p=0.006**
T_4	Intervention	8.1	[8.0; 8.2]	
	Control	5.5	[5.2; 5.8]	**p<0.001**
p-value for evolution over time per group (interaction term time*group)				**p<0.001**
Group	**Difference T_0-T_4**	**Mean Difference**	**95%CI**	**P-value**
Intervention	T_4-T_0	2.0	[1.8; 2.2]	**p<0.001**
Control	T_4-T_0	0.2	[-0.2;0.6]	p=0.28
Mean D_1				
Year	**Group**		**95%CI**	**P-value**
T_0	Intervention	1.1	[1.0; 1.2]	
	Control	0.9	[0.7; 1.0]	**p=0.02**
T_4	Intervention	1.2	[1.1; 1.3]	
	Control	1.3	[1.1; 1.4]	p=0.54
p-value for evolution over time per group (interaction term time*group)				**p=0.009**
Group	**Difference**	**Mean Difference**	**95%CI**	**P-value**
Intervention	T_4-T_0	0.1	[-0.001; 0.2]	p=0.05
Control	T_4-T_0	0.4	[0.2; 0.6]	**p<0.001**

Table 4.1: Mean Plaque Index (PI), mean knowledge scores and mean D1 score for intervention and control group at baseline (T_0) and after four year intervention (T_4).

Table 4.2 compares the proportions of completely treated children in both intervention and control group at T_0 and T_4. These proportions in both the intervention and control group increased after four years for all indices (CI, TI and RI). This increase was only statistically significant for the intervention group, although no statistically significant differences were found between intervention and control group, both at T_0 and T_4.

Variable	Group	% completely treated at T_0	% completely treated at T_4	Mean diff T_4-T_0	95%CI	p-value
CARE INDEX*	Interv.	48.8% (n=213)	61.4% (n=321)	0.12	[0.05; 0.20]	**p=0.002**
	Control	52.0% (n=75)	58.9% (n=107)	0.07	[0.08; 0.22]	p=0.35
TREATMENT INDEX*	Interv.	54.0% (n=213)	64.8% (n=321)	0.11	[0.03; 0.19]	**p=0.007**
	Control	52.7% (n=74)	63.6% (n=107)	0.11	[-0.04; 0.25]	p=0.14
RESTORATIVE INDEX*	Interv.	52.4% (n=206)	64.1% (n=315)	0.12	[0.04; 0.20]	**p=0.004**
	Control	52.1% (n=73)	63.2% (n=106)	0.11	[-0.03; 0.26]	p=0.13

Table 4.2: Proportions of 100%CI, 100%TI and 100%RI for intervention and control group at baseline (T0) and after four year intervention (T4).

*only for children with $D_3MFT>0$

The interaction "Maximum Bill by time" did not provide statistical evidence to assume that the 4-year intervention had a different effect for different social groups in the oral health outcome measures (table 4.3). Table 4.4 shows that significant differences between the social subgroups were present both at T_0 and T_4.

Variable	Model	P-value interaction term "Maximum Bill" * "time"
Mean Plaque Index	Mixed Model	0.38
D_1	Mixed Model	0.15
Knowledge	Mixed Model	0.99
100% CI proportion	Generalised Linear Model	0.20
100% TI proportion	Generalised Linear Model	0.35
100% RI proportion	Generalised Linear Model	0.30

Table 4.3: Multivariate models with T_0-T_4 and social status (Maximum Bill) as covariates, with corresponding p-values, with exclusion of the control groups.

Variable	Year	Max. Bill	N	Mean	P-value	Mean diff [95%CI]
PI	T0	No	861	0.69	**p=0.006**	0.15 [0.04;0.26]
		Yes	112	0.85		
	T4	No	828	0.37	**p=0.03**	0.10 [0.009;0.20]
		Yes	116	0.48		
D_1	T0	No	858	1.03	**p<0.001**	0.60 [0.32;0.88]
		Yes	111	1.63		
	T4	No	828	1.10	**p<0.001**	0.86 [0.53-1.20]
		Yes	116	1.97		
Knowledge	T0	No	859	4.93	**p=0.01**	0.48 [-0.86;-0.10]
		Yes	107	4.45		
	T4	No	760	6.52	**p<0.001**	0.51 [-0.80;-0.22]
		Yes	102	6.01		
				Proportion		
100% CI	T0	No	87	52.7%	**p=0.01**	
		Yes	10	29.4%		
	T4	No	160	63.7%	p=0.09	
		Yes	25	51.0%		
100% TI	T0	No	94	57.0%	0.09	
		Yes	14	41.2%		
	T4	No	166	66.1%	0.35	
		Yes	29	59.2%		
100% RI	T0	No	89	55.6%	0.06	
		Yes	12	37.5%		
	T4	No	162	65.6%	0.29	
		Yes	27	57.4%		

Table 4.4: Outcome measures at baseline (T_0) and after four years (T_4), for children with and without Maximum Bill intervention within the intervention group.

Discussion

The present data revealed that the oral health of both the intervention and control group significantly improved between 2010 and 2014. Following 1,058 children over the four-year period, statistically significant improvements were found for all outcome variables. However, according to the multivariate analyses, only the differences in knowledge and the number of decayed teeth could be independently attributed to the oral health promotion program itself. The decrease in plaque index seemed clinically stronger in the intervention group, resulting in significant differences between intervention group and controls at T_4. The authors would suppose that the intervention contributed to the reduction in dental plaque, although its independent impact was just not statistically demonstrated (p=0.053). For all other variables, similar oral health improvements were found when comparing two cross-sectional control groups, which are supposed not to be influenced by the intervention.

Regarding the mean number of untreated decayed teeth (at D_1-level), the intervention seemed to stabilise the number of decayed teeth over a four year period. There were no significant differences in the intervention group between baseline scores and scores after four years, whether the control group had a significantly higher number of decayed teeth after four years. This is noteworthy in itself and can be considered as a positive result of the intervention. The stabilisation or progression of the D-component is related to a balance between the occurrence of new decay and restoring existing dental decay.

The intervention group demonstrated a higher knowledge score of 2 points out of 10 after the four-year period. This finding proves that the oral health promotion program was very effective in improving children's knowledge, and should be an integral part of the school curriculum. Accordingly, there might be a link between the increased knowledge and the lower plaque scores which were seen after four years.

The proportion of completely treated children increased significantly in the intervention group. However, this improvement could not be linked to the intervention as such, since no differences between control and intervention group could be demonstrated at T_4. The control group showed a clinical improvement in care level as well, although this was not statistically significant, probably due to the smaller sample size of the control group. It is possible that the overall improvement in care level for all children is related to policy measures or mentality changes over the four year period. On the other hand, it is also possible that the oral health examination and referral letter led to the higher care levels in the control group, since this was the only predefined common factor between control and intervention group. It needs further research to investigate if less expensive and less time-consuming interventions, restricted to oral health examination and referral, can be as efficient to improve care levels in primary school children.

To reveal the possible impact of the oral health educational program on oral health inequalities, children's social status was put into multivariate models by means of the "Maximum Bill" variable. These models could not provide statistical evidence to assume that the intervention had a different impact on children with different social status. However, the statistical analyses as such are not sufficient to draw conclusions, because lack of statistical significance can be due to lack of statistical power. For this reason, univariate analyses were performed to demonstrate inequalities between the Maximum Bill group and the others at both T_0 and T_4. According to table 4.4, statistically significant inequalities were present in the intervention group for most of the oral health parameters, both before and after the intervention. In combination with the multivariate model, one can state that the intervention did not reduce the social gap, but did not widen it either.

However, it is very relevant to discuss more profoundly the methodological process of the present study. In fact, reporting the methodological pitfalls of the survey and its limitations might contribute more to oral health inequality research than the reported results themselves.

A first important limitation is the definition of a social indicator. In the Belgian context, it is very challenging to identify underprivileged subgroups, and to stratify children's social status. The Maximum Bill measure, which was used in the present survey, contains some important deficits as social indicator. First of all, the variable can only be calculated for children who have a medical insurance. Although this insurance is mandatory in Belgium, it includes children with a legal residence permit and those in line with the mandatory insurance. Consequently, families staying

illegally in the country or those who did not pay for their insurance will automatically be excluded for further analyses, although they can be both considered as vulnerable social subgroups. Furthermore, the index can only be used to dichotomise the observed sample in a group taking benefit from this measure and the others who did not. However, oral health inequalities are not dichotomised, but appear in a social gradient (Sanders *et al.*, 2006). Policy interventions should provide oral health promotion with the scale and intensity proportionate to the level of disadvantage, the so-called "proportionate universalism" (Marmot, 2010). In this philosophy, preventive interventions such as school programs should also be more adapted to the individual risk and preventive needs of school children. However, it remains challenging to execute this "personalised" risk-based approach in a school setting, without blaming or stigmatizing underprivileged subgroups. A region-based approach might be helpful, categorizing schools according to the deprivation level of their neighbourhood. In this way, it would be possible to provide standard preventive programs in the more wealthy areas and more intensive interventions in deprived regions, although this requires further research.

A final shortcoming of the Maximum Bill measure is its income-based character. In Belgium, health care policy and organisation are almost exclusively based on financial determinants, in particular family income. However, there are other factors which could describe residents' social context, such as educational level, employment and origin (Jarman, 1991). The authors would recommend policy makers to fine-tune the identification of socially vulnerable populations, in order to improve preventive interventions and health care organisation.

Another methodological issue to consider in long-term studies, especially when social determinants are included, is the loss of participants during the study period. The present study reported drop-out both at school level and on individual base. There was a response rate of 74% from all selected schools, but there was no additional information on the non-responding schools. In future research, it would be interesting to investigate if responding and non-responding schools have a comparable profile, in order not to widen existing inequalities between schools and areas.

Even more considerable is the low adherence at individual level. Starting from 6,533 children in the intervention group, only 1,058 children could be examined four times. Drop-out occurred in several stages. From 1,870 children, insurance state could not be determined, which means that the social status could not be reported either. Although, it is probable that a part of these children did not have a residence permit, leading to the complete exclusion of this social vulnerable group. Next, 213 children were excluded because they did not have a registered insurance status, which could be a social risk group either. In the remaining children of whom insurance was conforming to legislation, 950 children were eligible for the Maximum Bill system (21.3%). From the 1,058 subjects at T_4, the number of eligible children was 116 (11.0%). Although the multivariate models (table 4.3) could not provide statistical evidence to assume that the intervention had a different impact on different social subgroups, the reporting of the missing data suggests that these statistical results must be carefully interpreted. Indeed, purely mathematically calculated, the proportion of low-income children in the intervention group was reduced from 21.3% at baseline to 11.0% after four years, suggesting that these children were more likely to have missed one or more examinations. Consequently, they were also more likely to have missed part of the information, since the oral health educational program was partially provided on the same day as the oral health examinations. It is true that lower social status is associated with school absenteeism, which might partially explain the relatively higher drop-out rates in the children eligible to the Maximum Bill (Kearney, 2008).

The limitations of the present survey, which are openly described in this paper, can be of particular interest for future researchers. It is important to take into account that possible effects on oral health inequalities might not be determined by those who are left at the end of the survey, but by those who were lost on the way.

Conclusion

In general, the oral health of both the intervention group and control group improved between 2010 and 2014. Additionally, the Glimlachen.be® oral health promotion program has been effective in improving oral hygiene and oral health knowledge of primary school children over a four-year period. The intervention did not demonstrate statistically different evolutions over time between high-income and low-income children. However, the high drop-out rate, especially in children with the lowest social status, must be taken into consideration.

CHAPTER V

Including community oral health workers in an oral health care path targeting socially vulnerable high-risk groups: protocol of a prospective, two-year longitudinal cluster randomised controlled trial

LAMBERT M.[1], VANOBBERGEN J.[1], DE VISSCHERE L[1].

[1] *Department of Community Dentistry and Oral Public Health, Dental School, Ghent University, Belgium*

This chapter is an edited version of the manuscript, which was submitted for review in ***BMC Oral Health****.*

Abstract

Objectives: to present the design and piloting of a two-year longitudinal trial, integrating Community Oral Health Workers (COHW) in oral health care, by training and supporting dental professionals and social workers in poverty organisations.

Intervention: a two-day educational program for COHW's was developed and pilot-tested in a sample of 23 COHW's. Furthermore, an instrument was developed and validated to measure the effects of the training program on the knowledge and attitude of community oral health workers. In the longitudinal trial, COHW's will be trained to support and assist underprivileged families in optimising their oral health condition and in (re)integrating them into the regular oral health care system by building bridges between care seekers and care providers. Families in the intervention group will be compared to families only receiving the standard procedure of a referral letter for further treatment after standard oral examination.

Sampling procedure: all Flemish communities with a poverty index higher than 10% were clustered into 8 geographical zones, which were randomly categorized into 6 intervention zones and 2 control zones. In a next step, all poverty organisations will be asked to be involved in the study, to delegate COHW's and to set up a list of all potential participants within their clients (>1 year old). A random sampling procedure with replacement will be used at household level to select clients to the necessary number, which will be calculated in a power analysis.

Evaluation: the intervention will be evaluated yearly, both qualitatively and quantitatively, and the COHW's knowledge and attitude will be assessed. Process evaluation will be executed by means of six-monthly intervision sessions, yearly SWOT-analyses and in-depth qualitative interviewing. Clinical oral health outcomes, oral health behaviour and oral complaints will be assessed by means of a health examination survey and a self-administered questionnaire of 20 items. Linear mixed model analyses (continuous variables) and generalised mixed model analyses (dichotomous variables) will be conducted to evaluate changes over time. A "time by intervention" interaction term will be included in the models to evaluate differences in time evolution between the intervention and the control program. Univariate tests will be executed to analyse differences between intervention and control group before and after the study period. Regional differences, as well as differences at client level and between community oral health workers will be added in the multivariate models, to examine their possible impact on the oral health outcomes of the underprivileged individuals.

Introduction

In today's society, there are specific social subgroups with deprived oral health, leading to oral health inequalities and a social gradient (Sanders *et al*., 2006; Petersen & Kwan, 2011; Costa *et al.*, 2012). When underprivileged subgroups present with more oral diseases, it is not only an individual problem, but also a challenge at community level. According to calculations made by the International Centre for Oral Health Inequalities Research and Policy (ICOHIRP), global productivity loss due to oral diseases in 2010 was estimated at 138 Billion US dollars (Watt *et al.*, 2015).

It is of general interest to involve all members of society into preventive oral health and regular dental attendance. However, Sabbah *et al.* (2009) revealed socio-economic disparities in smoking behaviour, frequency of consuming fresh fruits, oral hygiene, and also dental attendance. These results might lead to the conclusion that the deprived oral health of underprivileged individuals is simply a consequence of their own deficient oral health behaviour. However, after adjusting for health behaviours in the statistical analyses, socio-economic disparities could not be eliminated. This suggests that oral health inequalities cannot be linked exclusively to compromising behaviour of the underprivileged groups themselves.

In oral health care for underprivileged individuals, there are important barriers, both at supplier-side and user-side. Dental anxiety can be an important user-side barrier, a factor which is related to educational level (Acharya, 2008; Egbor & Akpata, 2014). The importance of oral health care coverage should not be underestimated either (Palencia *et al.,* 2014). However, even in countries with universal oral health care coverage, such as Sweden, having financial problems was associated with reported refraining from seeking oral health care. (Berglund *et al.*, 2017; Hakeberg & Wide Boman, 2017).

Dentists can feel reluctant to treat underprivileged individuals. Possible frustrations in this respect can be missed appointments, more administration and low government fees (Bedos *et al.*, 2014). Bisgaier *et al.* (2011) experimented with 'mystery calls' in 85 dental clinics, showing that a Medicaid ensured resident got a dental appointment in 36.5% of the clinics, compared with 95.4% for a privately insured child with the same treatment need.

In order to build bridges between caregivers and care recipients, there can be a role for **community health workers (CHW)**, who are mainly involved within communities with scarcity of health workers. The term was introduced on PubMed database in 1971, where CHW's are defined as "*persons trained to assist professional health personnel in communicating with residents in the community concerning needs and availability of health services*". The involvement of CHW's in primary care showed to be an efficient way to guide underprivileged individuals towards preventive care and social services, reducing resource utilisation and community costs (Johnson *et al.*, 2012).

CHW's can also play an active role in oral health care. Benzian *et al.* (2015) composed a global competency matrix for oral health, involving many health professionals and groups in society, including CHW's. The authors identified four target groups, all of them having specific roles in the prevention, control, and management of oral diseases. A first group consisted of dental undergraduate students, specialists and dentists. In a second group, Community health workers were integrated, together with dental hygienists and dental therapists. Group 3 was formed by other

relevant health professionals, such as physicians, nurses, and pharmacists. The final group involved non-health professionals in the public arena, such as parents, teachers, policy makers, opinion makers and stakeholders. Since oral health care provision in Belgium is almost exclusively founded upon the shoulders of the dentist, a CHW can be a valuable intermediary in oral health promotion and referral to oral health care. Increasing oral health- related knowledge and awareness within poverty and welfare organisations might build bridges between care seekers and care providers by combining empathy for and knowledge about each other

This paper aims to present the design and piloting of a two-year longitudinal trial, integrating **Community Oral Health Workers (COHW)** in oral health care, by training and supporting dental professionals and social workers in poverty organisations (both voluntary and professional workers). The null-hypothesis is: "There is no difference in oral health, oral health behaviour and access to oral health care between socially vulnerable high-risk groups following a supervised oral health care path (intervention group with COHW) and socially vulnerable high-risk groups only receiving a referral (control group)".

Methods

A. Pilot study

Before implementing this nationwide survey and describing its long-term effects, several preparatory steps were required:

- development and validation of an instrument to measure the effects of the training program on the knowledge of community oral health workers
- development and validation of an instrument to measure the effects of the training program on the attitude of community oral health workers
- development and pilot testing of the educational program within a sample of community oral health workers

Development and validation of an instrument to measure the effects of the training program on the knowledge of community oral health workers

A questionnaire was developed as a tool to assess oral health-related knowledge. A first version of this questionnaire on oral health-related knowledge was composed by a panel of dental professionals (n=5). The questionnaire consisted of 20 multiple choice items with four answer options and only one correct answer per item. Each correct answer was associated with a score of 1, resulting in a maximum knowledge score of 20. The items were categorized into 4 domains:

- oral health versus oral disease and the relationship with general health (5 items)
- preventive oral health care (6 items)
- oral health for specific age groups and socially vulnerable groups (5 items)
- delivery and organisation of oral health care (4 items)

The questionnaire was proposed individually to three oral health experts to determine the face validity of each of the items. The experts were asked to mark the correct answer option and to indicate if the item was relevant and if the answer options were clear. For each item, additional comments could be given. When an expert found an answer option to be incorrect or unclear, or when 2 out of 3 experts indicated the item as irrelevant, it was abolished. Based on the additional comments, five items were reformulated before further validation.

Secondly, the questionnaire was sent to a sample of graduated dentists (expert group) and individuals with a different educational background (non-expert group). An independent-samples T-test was executed to compare both groups and to determine the discriminatory power of the questionnaire, supposing better scores for the expert group.

To evaluate the difficulty of the items, the proportion of correct answers for each item was calculated in the none-expert group. If this proportion was higher than 90% or lower than 10%, the item was omitted.

Development and validation of an instrument to measure the effects of the training program on the attitude of community oral health workers

In order to develop an attitude assessment tool, a questionnaire was developed by a Delphi panel of nine experts (six dental professionals and three psychologists), selecting 5 domains of relevance for community oral health workers:

- How do I look at myself in the context of oral health? (5 items)
- How do I look at the target population in the context of oral health? (5 items)
- How do I look at the dentist? (5 items?)
- How do I look at the changeability of oral health behaviour? (5 items?)
- How do I look at my self-effectiveness within the coaching process? (5 items?)

Each item was answered on a scale from 1 (fully disagree) to 5 (fully agree). The items were both negatively (n=16) and positively formulated (n=9). For the negatively formulated items, a score of 0 correspond to the best attitude, whether this was a score of 5 for the positively formulated items. In order to obtain a uniform attitude score, the negatively formulated items were inverted during the analysis of the results. Accordingly, the maximum attitude score was 125.

To determine content validity, these domains and items were firstly proposed to another expert panel of one psychologist and four dental professionals, and a sample of social assistants and volunteers within poverty organisations (n=10), corresponding to the profile of the community health workers. The sample included also non-native Dutch speakers, to assure that the questionnaire was also accessible for responders not having Dutch as first language. Based on their feedback, unclear words and expressions were changed.

Secondly, the questionnaire was filled out by first-year students of the 'Bachelor in Oral Health Care' education in Artevelde University College, in order to perform a factor analysis (principal component analysis).

To determine the internal consistency, the attitude questionnaire was sent to dental students in the 1st and 2nd Master year of education. Cronbach's alpha was calculated. According to Streiner and Norman (2003), a score between 0.70 and 0.90 should be acceptable.

One month after the initial survey, the same questionnaire was sent to the same sample of dental students. A paired-samples T-test was performed to investigate the intra-examiner reliability.

Development and pilot testing of the educational program

In order to provide adequate information and training to possible community health workers, an educational program was developed and piloted between August and December 2016. This educational program was based on the most recent evidence reported in the international literature, advices from the national Health Council and a validated oral health educational module for nurses (Claessens & De Visschere, 2009). This module was adapted to the profile of social workers within poverty and welfare organisations, and consisted of seven domains:

- The healthy mouth: normal development and anatomy of human dentition, including deciduous and permanent teeth
- Oral diseases, including dental decay, erosion, attrition, abrasion, periodontal disease and diseases of soft oral tissues. Also in this section, the relationship between general and oral health is explained.
- Preventive oral health, consisting of dietary advice, oral hygiene and fluoride use, smoking cessation and regular dental visits.
- Dental administration: this domain focuses on Belgian oral health care organisation, existing payment systems and governmental policy initiatives for different types of underprivileged individuals (residents with financial problems, asylum seekers and illegal immigrants).
- Motivational interviewing: in this section, emphasis is put on behavioural change, based on the model of Prochaska & Di Clemente (1983) and an online tool from the Flemish Association against Alcohol and Drugs.
- Case management: the main concepts of the previous domains are practiced and summarized by means of simulation cases.

The entire training was held during a two-day program. It was performed by one dentist and one psychologist, providing theoretical knowledge, clinical images, practical exercises and cases using an interactive PowerPoint presentation. In addition to the educational program, participants could consult and rehearse all information on a website (www.iedersmondgezond.be), which is specifically designed for the community health workers. Furthermore, all participants received the PowerPoint presentation slides of the educational program.

During the pilot survey between August and December 2016, community oral health workers were recruited in three pilot regions, after initial ethical approval of the ethical committee by the EC University hospital Ghent (No. B670201526486). Based on governmental information, all known local poverty organisations were asked by email to delegate participants for the educational program, resulting in a pilot sample of 23 participants, representing 12 different poverty organisations in 3 regions.

A pre- and post-test was used to assess the impact of the educational program on the knowledge and attitude of the participants. Questionnaires evaluating knowledge and attitude were completed at baseline (just before the educational program) and one month after the program. The post-test questionnaire was sent by email, using an online version of the questionnaire in Google Forms. A unique code for every participant enabled anonymous comparison between both questionnaires, using Repeated Measures ANOVA statistical tests.

Besides quantitative analysis, a process-evaluation of the educational program was executed by means of individual qualitative interviewing. In this in-depth interview, participants were asked to provide more information about the educational program itself (content, structure, teaching methods) and its possible impact on their daily work. Those who already supported their clients as a community oral health worker during the pilot survey period, were questioned about their experiences and the contact with both clients and dental professionals. They could also indicate persisting barriers.

B. Longitudinal study

General study concept

This prospective, two-year longitudinal randomised controlled trial will investigate the effects of including COHW's in a preventive and curative oral health care path targeting high risk groups.

Within the present protocol, a COHW is defined as a **social worker having a tight relationship with underprivileged individuals and, after an educational program, having sufficient knowledge about the different aspects of oral health and oral health care, in order to support their clients through information and education, advocacy and social support**. They can be either professionally employed within their organisation, or voluntary workers. They usually share or are experienced with the ethnicity, language, socio-economic status, and living conditions of the community members they serve.

These COHW's will be trained to support and assist underprivileged families in optimising their oral health condition and in (re)integrating them into the regular oral health care system by building bridges between care seekers and care providers. They can be considered as a personal family coach, but they are legally not allowed to perform any professional intra-oral action.

The process of individual coaching by COHW's will be evaluated both qualitatively and quantitatively. Families in the intervention group will be compared to families who only receive the standard procedure of a referral letter for further treatment after standard oral examination, without personal coaching (controls).

Poverty and welfare organisations: population and study sample

Flanders and Brussels Capital Region consist of 327 communities. Based on the poverty index of the Flemish government, it is possible to calculate the level of deprivation of each community. In view of the feasibility of this RCT, it was arbitrary decided to only include communities with a poverty index higher than 10% (fig. 5.1). This resulted in 101 communities, clustered into 8 geographical zones. The

8 zones were randomly categorized into 6 intervention zones (71 communities) and 2 control zones (30 communities).

A list of all poverty and welfare organisations being active in the 101 selected communities of the 8 study zones was made, using the official Flemish governmental databases. Both professional and voluntary-based organisations were included. Additionally, 4 scientific co-workers individually explored the internet to possibly add other poverty organisations, resulting in a comprehensive list of 536 contact addresses.

All 536 contact addresses will receive a standard email with information about the survey and an invitation to apply for further information. Two weeks later, a reminder will be sent. The pilot survey, which followed the same selection procedure in 4 cities, revealed that organisations were more likely to participate after a personal contact. For this reason, all interested organisations will be contacted by phone to provide additional standardised information on the study concept and to answer possible questions. During this phone call, a personal visit to the organisation will be scheduled to provide final practical information to all relevant actors within the participating organisations.

When organisations in the intervention zone agree to participate, their team members can volunteer to be involved as a COHW. The number of COHW's per organisation will depend on the size of the organisation, and based on a ratio of 15 individuals per COHW.

Organisations in the control zones will be invited to take part in the control group, receiving annual oral health examinations with referral letter, but without personal coaching by a COHW. All organisations in the control group will also receive the offer to apply for the two-day educational program after the study period.

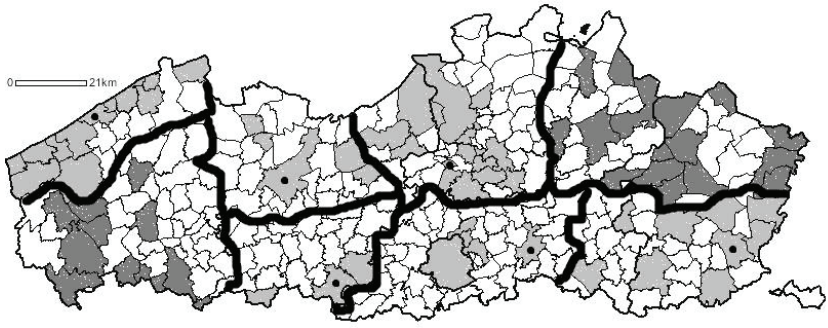

Fig. 5.1: Geographic zones in Flanders randomly allocated to 6 intervention (light grey) and 2 control zones (dark grey). All coloured communities have a deprivation index >10%. The central locations of the educational program sessions are indicated with a black spot.

Clients of poverty and welfare organisations: sampling procedure

Organisations of both the intervention and control group will be asked to set up a list of potential participants within their clients (>1 year old). The inclusion criterion to be selected is the level of

deprivation. “Kind & Gezin” (“Child & Family”), a Flemish organisation providing primary health care to new-born children until the age of three, determined six criteria to measure deprivation:

- Family income: there is no fixed monthly income or the family income (decreased with existing debts) is lower than the national living wage. In Belgium, this was €1.190,27/month at the first of September 2017, for a family with at least one unmarried child. (http://www.mi-is.be/nl/equivalent-leefloon).
- Educational level of the parents: at least one of the parents has no diploma of higher secondary school, exclusively attended schools for special educational needs, or is illiterate.
- Maturation of the children: no or irregular attendance of nursery education, parents experience difficulties in the care of their children
- Professional status of the parents: precarious employment (e.g. temporary contracts), sheltered work, or both parents are unemployed
- Housing: dilapidated, unhealthy and/or unsafe housing, no or deficient utilities
- Health: poor health status of the family members, low health literacy and participation, chronic illness, handicaps.

According to these criteria, families will be considered as underprivileged when they meet at least 3 of the 6 criteria. A random sampling procedure with replacement will be used at household level to select clients to the necessary number, which will be calculated in a power analysis.

Crucial factors for calculating the sample size (n) are the presumed distribution of the most important outcome measures (oral hygiene level, periodontal status, untreated caries, caries severity, and the level of restoration) in the target population (σ), the presumed effect of the intervention (μ1 – μ2), the power required (1-β), the a priori determined level of significance (α), and the value of the intraclass correlation (design effect). An a priori power of 80% and a level of significance of 0.05 are predetermined. The design effect (Deff) represents the ratio of the number of residents required using cluster randomization to the number of residents required using individual randomization. Previous screenings during the pilot survey (n=362), provided an estimate of the most important outcome variables (table 5.1).

Outcome variable	Mean	SD
Sillness-Löe plaque-index	1.11	0.8
DMFT	7.61	8.27
Restorative index	49%	34.87
PUFA	1.5	3.53
	Proportion	
DPSI ≥2	85.3%	

Table 5.1: Mean scores and SD for the principal outcome variables, resulting from a pilot study within the target population (n=362)

One day before the oral health examination, clients will receive a text message to remind them of their appointment. Written informed consent will be obtained at the time of the baseline oral health examination. For the intervention group, the first oral health examination and interview will be carried out in the presence of the COHW, in order to strengthen the relationship between clients and

COHW's. Those clients who agreed to participate but don't show up for the oral health examination, will be contacted by phone to register the reasons for non-attendance.

Educational program

The two-day educational program will be held in each of the six intervention zones, at a central location which is indicated as a black spot on figure 5.1. COHW's who cannot attend one or both days of the educational program in their own region, can follow the courses at one of the other locations.

As described in the pilot study section, the educational program comprises development and anatomy of human dentition, the most common oral diseases, preventive oral health care, dental administration, motivational interviewing and case management. The training will be performed by one dentist and one psychologist, providing theoretical knowledge, clinical images, practical exercises and case discussions using an interactive PowerPoint presentation. In addition to the educational program, participants will be able to consult and rehearse all information in a syllabus and on a website (www.iedersmondgezond.be), which were both specifically designed for the COHW's. Furthermore, all participants will receive the PowerPoint presentation slides of the educational program, together with quick reference cards as summary of every chapter. Every six months, all COHW's will be invited to an intervision session per region, in order to repeat the basic information, to discuss the coaching procedure and to learn from each other.

The qualitative results of the pilot survey, one month after onset, revealed that the educational program helped the COHW's in supporting their clients, especially regarding dental administration and making a dental appointment. Nevertheless, the COHW's gave the scientific team the advice to inform all dental practitioners about the survey and to stimulate them to be involved in the curative and preventive care path of the individual clients. For this reason, a standard email with information will be sent to all dental practitioners in Flanders. As part of the intervention, all dentists in the intervention zones will be contacted by the COHW's, to ask them to accept new clients from the poverty organisations.

Community oral health workers tasks

After the educational program, the COHW's will be asked to individually coach 15 clients in their preventive and curative oral health care path. COHW's should be competent to accomplish following tasks:

- Providing culturally sensitive oral health education and advocacy during the baseline oral health examination.
- Supporting clients with health insurance administration.
- Connecting participants to the primary oral health care services and removing barriers interfering with participants' ability to access primary care.
- Accompanying clients to the dentist on the first appointment and providing support and advocacy during dental visits if necessary.

- Understanding the importance of adherence with treatment plans and reminding participants of their next dental appointments, without accompanying them, in order to increase clients' self-empowerment. In case of missing an appointment (no show) by the client, the level of personal assistance will be re-evaluated in communication with the client and the dentist. If the client's self-efficacy and compliance seem to be deficient, the coach will be required to accompany him/her on the next appointment(s).
- Promoting oral health behaviour and encouraging participants to make healthier lifestyle choices.
- Reporting all interventions and contacts with clients in a logbook to have a clear overview of the specific workload of the oral health care path.

Each COHW will receive a small budget of €20 per client, for personal transport and the provision of basic oral hygiene devices and other expenses related to the coaching procedure.

Oral health examination

Before the start of the individual coaching process, all participating clients will be invited for a clinical oral health examination, comprising clinical examination of the oral cavity and teeth using a dental mirror and probe according to pre-established criteria. The oral health examination will be conducted at the poverty organisation in a separate and well-lit room using an ordinary chair and a head lamp (Eijlander Electronics, Ede, the Netherlands) to improve visibility.

Oral health examination will be conducted by 5 trained and calibrated dentist-examiners. Calibration will be undertaken to avoid bias, using a series of full-mouth photographs simulating the clinical examination.

To measure caries experience, DMFT/dmft score will be used as one of the outcome variables, counting the number of decayed (measured at cavitation into dentine level (D_3), according to WHO criteria), missing and filled teeth (Klein *et al.*, 1938). By consensus, edentulous patients are considered to have a DMFT score of 28, but being completely edentulous will also be separately analysed and reported as a dichotomous parameter. Untreated decay will be determined by the D/d component >0 and used as a continuous outcome variable in the analyses. Derived from the DMFT/dmft, the Restorative Index (RI=(FT/(D_3+FT))*100), Care Index (CI=FT/(D_3+M+FT)*100) and Treatment Index (TI= (M+FT)/(D_3+M+FT)*100) will be calculated. All three indices are ranging from 0 to 100%.

The PUFA index, which is the sum of the teeth with pulp exposure (P), ulcerations (U), fistulas (F) and abscesses (A) due to caries, will be used to score the severity of present caries lesions.

Periodontal health will be determined by means of the DPSI score (Dutch periodontal screening index, ranging from 0 to 4), for participants older than 15 years (Van der Velden, 2009). The highest DPSI score among the sextants of each client was considered the clients' DPSI score. The variable will be used as a dichotomous binary outcome variable in the analyses (DPSI<2 vs DPSI≥2).

The presence of dental plaque will be assessed using the Sillness and Löe plaque index. The outcome variable is continuous and represents the mean buccal surface plaque score of six reference teeth on

a scale from 0 (no plaque) to 3 (visible plaque accumulation on more than one third of the buccal surface) (Silness and Löe, 1964). In case of absence of a reference tooth, the buccal surface of the adjacent tooth will be examined as substitute. Subjects with no natural teeth will be excluded for this parameter.

Chewing functionality will be assessed by counting the number of occluding pairs, starting from the first premolar, with a maximum score of 8. The number of occluding pairs will be measured both with and without removable dental prostheses.

Oral health questionnaire

In addition to the oral examination, clients will be interviewed, using a shortened version of a self-administered questionnaire which was previously used and validated by Declerck *et al.* (2013). The questionnaire consists of 20 items covering socio-demographic information (age, gender, nationality, country of birth, educational attainment, occupational status), oral health behaviour (frequency of tooth brushing, dietary habits, number of non-urgent dental visits in the last year, smoking habits), presence of oral complaints in the past 4 weeks, and general health information (chronic diseases or disabilities, diabetes, medication use). Dietary habits will be assessed by indicating the frequency of consuming various foods and drinks (more than once a day, once a day, more than once a week, once or less than once a week, never). Presence of oral complaints in the preceding 4 weeks comprises toothache during the consumption of warm/cold food or drink, temporomandibular pain, other oral pain or discomfort and bleeding gums. Answer options are “no pain”, “slight”, “moderate”, “intense” or “extreme” for the orofacial pain and “no”, “during brushing or eating” or “spontaneous” for the bleeding gums. Smoking habits will be examined in clients >12 years old and are categorised into “daily smoker”, “occasional smoker”, “ex-smoker”, “none-smoker”

The self-administered questionnaire will be presented in paper form and explained by a non-dental examiner, in presence of the community oral health worker, prior to the oral health examination. Data of children younger than 12 will be obtained by a proxy.

Both the clinical oral health examination and the oral health questionnaire will be repeated yearly, in order to evaluate evolutions in oral health and oral health behaviour over the two-year longitudinal survey.

Data analysis

Data analysis will be carried out in the IBM SPSS Statistics V24.0 (SPSS Inc., Chicago, IL, USA). After explorative data analyses, linear mixed model analyses (continuous variables) and generalised mixed model analyses (dichotomous variables) will be conducted to evaluate changes over time. A “time by intervention” interaction term will be included in the models to evaluate differences in time evolution between the intervention and the control program.

Univariate tests will be executed to analyse differences between intervention and control group before and after the study period.

Regional differences, as well as differences at client level and between community oral health workers will be added in the multivariate models, to examine their possible impact on the oral health outcomes of the underprivileged individuals (table 5.2).

For all analyses, alpha is set at 0.05.

Independent variables	Type	Outcome variables	Type
Client level		**Oral health behaviour Client**	
Gender	Nominal	Food consumption	Ordinal
Household size	Continuous		
Age group	Ordinal	Smoking habits	Ordinal
Insurance status	Nominal	Number of dental visits in the previous year	Continuous
Educational attainment	Ordinal	Self-reported frequency of tooth brushing	Ordinal
Occupational status	Ordinal	**Oral health Client**	
Nationality	Nominal	DMFT/dmft	Continuous [0-32]
Country of birth	Nominal	Untreated caries (D>0)	Dichotomous
Nationality mother	Nominal	Care Index	Continuous [0-100%]
Regular dental attender	Dichotomous	Restorative Index	Continuous [0-100%]
COHW level		Treatment Index	Continuous [0-100%]
Gender	Nominal	PUFA	Continuous [0-32]
Age group	Ordinal	Plaque index (PI)	Continuous [0-3]
Educational attainment	Ordinal	Low/high plaque score	Dichotomous
Occupational status	Ordinal	Edentulousness	Dichotomous
Oral health Knowledge	Continuous [0-20]	DPSI	Ordinal
Oral health Attitude	Continuous [0-125]	Occluding pairs	Continuous [0-8]
Regional level			
Zone	Nominal		

Table 5.2: Summary of the independent and outcome variables.

Process evaluation of the intervention

During the two-year survey period, COHW's will be in direct contact with oral health experts, in order to discuss individual cases and to solve possible problems. All individual contacts between COHW's and co-workers of the knowledge centre will be registered in a database, recording the time and

duration, the medium (mail, phone, personal contact) and the subject of the contact. This information, which will be processed anonymously, will provide valuable insights in the intervention.

Every six months, all COHW's will be invited to participate in focus group discussions, which will be held in each zone. During these intervision sessions, COHW's will learn from each other by sharing both positive and negative experiences. Persisting needs and barriers will be discussed in group.

On a yearly base, a SWOT analysis will be performed to determine the Strengths, Weaknesses, Opportunities and Threats of the intervention. All participating COHW's, dental professionals and clients will be invited to take part in this SWOT-analysis. Clients will be asked to complete a written questionnaire at the time of the yearly oral health examination, while the COHW's and dentists will receive an email with an online form.

At the end of the survey, a random sample of clients, COHW's and dentists from each region will be selected for an in-depth, face-to-face, semi-structured interview on the implementation of the preventive and curative care path. Main questions of the semi-structured interview will comprise the impact of the intervention on oral health, oral health behaviour and access to oral health care, the balance between time and work investment and observed gains, and persisting needs and barriers which could not be solved by the intervention.

Protection of personal data and private life

Clinical data will be stored in a database specially designed for the survey, using VTiger CRM system 7.1.0RC. The database, including personal data, will be protected by an external hosting company and will not be able to be consulted or modified by a third party. Before data analysis, all records will be encrypted to ensure anonymity.

Ethics

Ethical approval for the longitudinal survey was obtained by the EC University hospital Ghent (No. B670201734557). All procedures were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

All COHW's and all clients will be asked for written informed consent prior to data collection. For children younger than 12, informed consent will be signed by one of the parents. and for children between 12 and 18 years old informed consent of both child and parents will be asked. Informed consent will be signed at the time of the oral health examination.

All COHW's are required to sign a form to ensure confidentiality of the (oral) health information they obtain during the coaching procedure.

As a summary, table 5.3 provides a flowchart of the longitudinal study

1	**Listing of all Flemish communities with a deprivation index >10%**
2	Definition of 8 geographical zones
3	Random selection of 6 intervention zones and 2 control zones
4	Standard email to all local poverty and welfare organisations + reminder
5	Standard phone call and personal visit to all interested organisations
6	Selection of clients based on the sample size calculations
7	Selection of the COHW's based on a ratio of 15 clients per COHW
8	Two-day educational program on a central location in the six intervention regions
9	Baseline oral health examination and oral health questionnaire in all participating organisations
10	Start of the intervention: preventive and curative oral health care path
11	Half yearly focus groups with COHW's
12	Yearly repeated oral health examination and oral health questionnaire in all participating organisations
13	Semi-structured interviews at the end of the survey, in a random sample of clients, COHW's and dentists from each region

Table 5.3: Flowchart of the study protocol.

Results (pilot survey)

Validation of the knowledge questionnaire

Comparison of the knowledge scores between the oral health expert group (n=18) and the none-expert group (n=16) resulted in significantly higher scores for the group of dentists (mean diff: 9.4; 95%CI=[7.8-11.1]). According to this known-groups analysis, the knowledge questionnaire could demonstrate sufficient discriminatory power.

The proportion of correct answers within the none-expert group ranged between 10% and 90% for all of the items, suggesting that the difficulty of the items was not extremely low or high. All 20 items were retained in the final questionnaire.

The questionnaire can be considered as a valid tool to measure oral health knowledge.

Validation of the attitude questionnaire

Factor analysis within first-year 'Bachelor in Oral Health Care' students (n=78) revealed that 3 of the 25 items showed a low coverage. However, the experts decided to retain these items, giving priority to the content of the item above the possibility to shorten the questionnaire.

After one month, 19 students completed the questionnaire a second time to test the intra-examiner reliability. Paired sample T-test did not provide statistically significant differences between the scores at baseline and after one month, implying that the attitude scores were consistent at different time points (p =0 .222; T= -1.265, df= 18).

Regarding internal consistency, the attitude questionnaire was completed by 48 dental students. Cronbach's Alpha was 0.77, suggesting that the questionnaire could be considered as internally consistent. Further analysis revealed that the Cronbach's Alpha did not significantly change by omitting each individual item, indicating that all of the items fit to each other.

Consequently, the questionnaire of 25 items can be used as a reliable instrument to measure attitude towards oral health.

Pilot testing of the educational program

The educational program was tested in three pilot cities, Ghent (n=8), Leuven (n=8) and Antwerp (n=7). According to table 5.4, mean age of the participants was 45 (SD=13.84), and most of them were higher educated (82.6%) and had Dutch as their mother language (78.3%). Ten participants were professionally active within their organisation and nine were voluntary workers.

	N	%
City		
Ghent	8	34.8
Leuven	8	34.8
Antwerp	7	30.4
Mother language		
Dutch	18	78.3
Other	5	21.7
Educational level		
Higher education	19	82.6
Higher secondary education	4	17.4
Professional status within the organisation		
Professional	10	43.5
Volunteer	9	39.1
Missing	4	17.4

Table 5.4: demographic characteristics of the pilot sample (n=23)

Mean attitude score before the educational program was 86.0 out of 125 (SD=4.6), and mean knowledge score was 6.5 out of 20 (SD=3.1). Nineteen participants completed the questionnaire after one month (82.6%). The mean knowledge score significantly increased by 4.8 points, to 11.3 (SD=2.5) ($p< 0.001$). Post-test attitude score was 88.2, but no statistically significant difference compared to the pre-test could be demonstrated.

Five participants agreed to undergo an in-depth interview, to provide a qualitative evaluation of the educational program and the initial phase of the work as a COHW. All of them reported having learnt a lot from the educational program. Furthermore, the program was described as an accelerator to provide access towards oral health care for their clients. However, more emphasis should be put on the practical implementation of the theoretical concepts, by providing specific examples from daily life situations, especially regarding preventive oral health and motivational interviewing.

The aspects about the healthy mouth and oral diseases were considered as very informative, although some of the participants wondered if the information was accessible to participants of all educational backgrounds. However, none of them perceived the educational program as too difficult for themselves.

Regarding the initial phase of the work as a COHW, the five COHWs indicated that the increased knowledge of dental administration enabled them to support and inform their clients before making a first dental appointment. The educational program led to better understanding of dental treatments and their possible financial implications. They appreciated the accessibility of oral health experts during the survey period, providing additional information about specific cases. All five participants stressed the importance of a personal contact with the dental practitioner prior to the first dental appointment, in order to inform them about the protocol and objectives of the study and about their particular tasks as a COHW.

Persisting barriers perceived by the COHWs were mostly related to financial aspects. Clients who were not eligible for increased allowance and accordingly were excluded for third-party payment, experienced difficulties to advance the dental fee. For those who were eligible, it was hard to find a dentist who wanted to apply third-party payment. Furthermore, the lack of reimbursement of tooth extractions under the age of 53, which is stated by Belgian legislation, was an important barrier, resulting in dental avoidance.

Discussion

The initial pilot survey aimed to validate a questionnaire on oral health-related knowledge and attitude, and to test a two-day educational program for community oral health workers.

The knowledge questionnaire had sufficient discriminatory power, whether the attitude questionnaire was internally consistent. Accordingly, both questionnaires can be used as a valid and reliable tool to measure oral health-related knowledge and attitude.

The educational program was pilot-tested in a rather small sample of 23 participants. One month after the educational program, the mean attitude score did not change, which is not surprising after only one month. The mean knowledge score increased by almost 5 points. This can be considered as a positive effect, although it needs to be carefully considered. First of all, the small sample cannot be considered as a representative sample to draw conclusions. Secondly, the present effects are only short-term, and do not assure sustainability over time. Thirdly, the mean knowledge score increased to a score of 11.3 out of 20. It is questionable if this score correlates to sufficient oral health-related knowledge to support underprivileged individuals.

The vast majority of the pilot sample was higher educated. Since the sampling procedure is identical in the pilot survey and the longitudinal survey, it can be supposed that the call for COHWs in the longitudinal survey will also mainly attracts higher educated subjects. Since the qualitative interviews questioned the accessibility for all educational backgrounds, the difficulty of the educational program needed to be overthought, as well as how to involve COHW's with different educational background.

After the pilot survey, some specific actions were taken to make the information more accessible and comprehensible. In the educational program, more emphasis was put on visualisation and specific daily-life examples. The syllabus, which was composed by dental experts during the pilot phase, was read and adapted by a communication expert without any dental knowledge, in order to eliminate technical jargon and to improve attractiveness and readability. Per chapter, quick reference cards containing images and bullet points were developed as a summary. Finally, six-monthly intervision

sessions will provide an update on the main oral health information and aim to maintain and improve knowledge by continuous learning.

After the pilot survey, persisting barriers were mostly related to financial aspects. It was difficult to find dentists, especially those who agreed to work with a third-party payment. Furthermore, the age limit for reimbursement of certain treatments remained a considerable barrier to seek oral health care. However, only 5 COHW's participated in the process evaluation of the pilot survey, which cannot lead to generalisable conclusions.

Even when financial barriers are indicated during the pilot survey, it is important to execute the longitudinal study within real-life circumstances, instead of providing supplementary budgets to the clients for non-covered treatments. First of all, providing private funding for oral health care is not a structural solution, and is unfair towards those who cannot participate in the study. Secondly, it would be impossible to test the independent impact of the COHW's, resulting into confounding. Finally, an important aspect of the study is to inform policy makers and stakeholders about persisting barriers to oral health care access, even when all existing structures are utilised with the support of the COHW.

The longitudinal survey probably will contribute to better knowledge about the involvement of community health workers in oral health, and their possible impact on the oral health, oral health behaviour and access to oral health care of underprivileged individuals. Greenberg *et al.* (2008) demonstrated the positive impact of dental case managers on Medicaid beneficiaries' (low-income individuals) use of dental services and the number of dentists participating in the Medicaid program. The present survey will be implemented in a European country with universal oral health care coverage, and will investigate the additional impact of the intervention on underprivileged families' oral health and oral health behaviour. A two-year longitudinal survey will be conducted to observe possible sustainable behavioural changes and structural improvements in access to oral health care on long term.

The use of COHW's is an intermediate link to (re)integrate underprivileged individuals in regular oral health care. It aims to support both clients and dental practitioners to overcome initial barriers, and to gradually increase independence and self-empowerment. Generating separated care paths and mobile care should be avoided as much as possible, in order not to stigmatise underprivileged individuals and not to create upper- and lower-class oral health care. The authors belief that all socio-economic subgroups can be integrated in both private and public health care, when appropriate support is available.

In order to limit cross-regional influence between intervention and control groups, the authors preferred to predefine 8 geographical zones, which were randomised into 6 intervention and 2 control zones. If randomisation would be performed at community level and all 101 communities would be mixed into control and intervention communities, it would be almost impossible to avoid influences from intervention communities on adjacent control communities. Furthermore, most poverty organisations are strongly locally embedded and form networks with neighbour organisations. It was one of their strongest demands to avoid a sense of 'injustice' within the target population, when one community would receive more support than the neighbour municipality.

Setting up the present study and performing the pilot testing, it became clear that it is hard to perform a randomised controlled trial in poverty organisations. Guided by their sense of justice and helpfulness, all organisations in both intervention and control zones want to support their clients as much as possible, possibly leading to biased results in the control group, especially because the survey website (www.iedersmondgezond.be) with additional information is freely available on the internet. Organisations in the control zones will be allowed to receive the intervention after the study period, but are asked not to intervene by improving their services during the first two-year period, in order to avoid bias as much as possible.

The fact of being observed can also lead to a behavioural change, known as the Hawthorne effect. Additionally, this Hawthorne-effect can be reinforced by the referral letter which will be given to all clients in both intervention and control group. This letter can act as an incentive to more intensively seek care than clients would do without. All these factors can contribute to a significant positive effect on oral health outcomes in the control group.

A voluntary-based sampling strategy will be performed to select poverty and welfare organisations and COHW's. Although all known organisations will be invited, it is assumable that the best-structured organisations and the most interested social workers will be more likely to respond, according to the Matthew effect (Perc, 2014). Similarly, clients will be invited for a free oral health examination within the organisation. Again, it is probable that the profile of the clients showing interest for the survey will not be representative for all underprivileged individuals, and that the most interested will be more likely to be selected. However, it can be supposed that this double selection bias, both at organisation and client level, will be similar in control and intervention zones, assuming a random selection bias. Furthermore, responder versus non-responder analyses will be performed at client level, in order to compare the profile of clients who participated in the survey and those who initially agreed but did not participate.

An important aspect within the present survey is to refine the profile of COHWs. Until present, there are no further criteria on educational background and professional qualification, because the COHW as described in this chapter, is a new concept. Consequently, there is no evidence yet to pre-set any criteria. The main goal of the COHWs is to target the most vulnerable as close as possible, which means that COHWs preferably should act in the direct environment of the target population, and already have a close relationship with them. By training social workers of existing poverty organisations, creating new structures with possible new barriers can be avoided.

A good balance needs to be found between professional and educational qualifications and being close to the target population. A higher educational qualification might lead to more professionalism and more knowledge, but it might also create a greater social distance between the COHW and the target population. It needs further research to investigate where to put the COHW on the scale from peer tutor to professional worker.

Of course, it is important to make sure that people get correct information and high-quality support. For this reason, COHWs' oral health related knowledge and attitude will be assessed before and after the educational program. Also their professional status and educational attainment will be used as an explanatory variable, in order to examine the impact of these variables on the oral health outcomes of the target population. Every six months, focus group discussions will be held to update knowledge and skills and to detect possible problems.

Acknowledgement

The authors would like to express their gratitude towards the Flemish Ministry of Welfare, Public Health and Family, for providing indispensable support and resources to conduct the present survey, in collaboration with the Flemish Institute of Oral Health (“GezondeMond”).

GENERAL DISCUSSION

The general aim of the present research was to assess oral health inequalities in Belgium, and to gain better understanding of measures dealing with social disparities. More specific objectives were to explore the existence of oral health inequalities in Flanders, the Dutch-speaking region in Belgium. Therefore, cross-sectional epidemiological research was performed in both children (**chapter I**) and adults (**chapter II**). Secondly, the present research aimed to update the knowledge on existing interventions to reduce oral health inequalities worldwide (**chapter III**). Based on this, a four-year longitudinal survey was performed in Belgian primary school children to determine the capability of an oral health promotional program to reduce inequalities between low-income children and their more privileged peers (**chapter IV**). Based on these findings, the final objective of this doctoral thesis was to develop a preventive and curative oral health care path, mediated by Community Oral Health Workers (COHW's) (**chapter V**), targeting underprivileged individuals.

Although the overall oral health is improving worldwide, oral health inequalities remain an important challenge, both globally and nationally (**introduction, chapter I and chapter II**). Identifying high-risk groups provides valuable information to set up preventive oral health programs and to optimise the existing oral health care system. In the ideal situation of optimal primary prevention, oral health programs should target subgroups at higher risk before they present with oral diseases, and not as a reaction on higher disease levels.

According to **chapter I**, the oral health status of 11-12 year-old children eligible for the maximum Bill measure (as an indicator for being underprivileged) was quite good, showing 78.4% of them being completely caries-free (DMFT=0), compared to 88.4% of the other children. Although these figures are promising, only half of the low-income children could be considered as regular dental attenders, bearing a risk of future oral health problems. From those with DMFT>0, only half were completely treated. These oral health outcomes were all strongly significantly different from the children who were not entitled to the Maximum Bill. Although this cross-sectional survey is not able to uncover causal relationships, the key role played by the family and environmental context in children's dental attendance needs to be considered and further investigated. It is clear that 12-year old children cannot be taken fully responsible for being a dental non-attender. A systematic review of Castilho *et al.* (2013) revealed that parental oral health habits affects children's oral health. For this reason, the authors of this review state that oral health promotion programs need to put emphasis on the entire family context, concerning their lifestyle and oral health behaviour.

Regarding the economically active adults (**chapter II**), mean DMFT score was 11.0 (SD=7.0). The WHO published a map with mean DMFT-scores for all different regions worldwide (Petersen *et al.*, 2005). For the age group 35-44yrs, the mean DMFT in Western Europe exceeded 13.9. For the same age group in the present sample of Belgian adults, mean DMFT was 10.3 (SD=6.0), which is lower than the figures of Petersen *et al*. However, the data presented by the WHO were collected almost 10 years earlier. Furthermore, it is hard to interpret and to compare DMFT scores in adults. DMFT is not only confounded by age, but also by the treatment intentions of dentists. In a cross-sectional design, it is difficult to assign an exact value for the M-component. Assigning the maximum possible value for the M-component leads to overestimation of an individual's caries experience, whereas assigning the minimum possible value for the M-component has the opposite effect. For this reason, the D-

component of the score was treated as a separate variable to count the real number of decayed teeth at the time of examination.

Untreated decay is a widespread problem in Belgium, showing proportions of 34.7% in the economically active population. The present findings are comparable to those reported by Kassebaum *et al.* (2015). In this systematic review and meta-regression analysis, the prevalence of untreated dental decay in the permanent dentition in 2010 was 35.8% (95%CI=[33.1–39.0]) in Western Europe and 35.4% (95%CI=[33.7–37.3]) globally.

Apart from the overall figures, the present research revealed socio-economic disparities in oral health outcomes (**chapter I and II**). To effectively reduce (oral) health inequalities, Marmot (2010) introduced the principle of proportionate universalism, providing health promotion with the scale and intensity proportionate to the level of disadvantage. However, this principle is not well-established in oral health promotion (**chapter III**). A first important issue to consider in preventive oral health interventions, is the identification of subgroups with a higher level of disadvantage. In other words, ***whom should be targeted***?

Marmot stressed the importance of education and employment to reduce health inequalities. This importance was also reflected in the five different deprivation indices which were presented in the introduction section (Townsend, 1988; Jarman, 1991; Carstairs & Morris, 1991; Ghent deprivation atlas, 2002; Child & Family, 2010). All of them included employment status as a determinant of social deprivation, while two mentioned educational level. The results of the present research contributed to this knowledge (**chapter II**). The proportion of adults with untreated tooth decay was the highest in those having lower secondary education as highest educational degree. Furthermore, multivariate analysis revealed an association between untreated tooth decay and unemployment, especially in the age group under the age of 25. Apart from dental caries, edentulousness was almost eight times more present in unemployed individuals. In chapter II, educational level was the only parameter capable of demonstrating a social gradient, since all other explanatory variables were dichotomised. Ranking educational level from low to high, a decreasing trend in the proportion of edentulousness is seen (12.3%; 5.3%; 2.4%; 0.6%). However, only the difference between the highest educated and the lowest educated subgroup was statistically significant. Multivariate analyses demonstrated the independent association between employment and edentulousness, which was mainly explained by differences in female participants.

The present research also found an association between ethnicity and oral health outcomes (untreated dental decay and D_3MFT) in adults (**chapter II**). Being born in a non-western country, or still having a non-western nationality, was associated with higher levels of untreated tooth decay. However, these results should be interpreted with caution. Although adults with a non-western origin had the worst oral health outcomes in absolute figures, multivariate statistical analysis revealed that the differences between native Belgians and participants from other western countries (who had the most favorable oral health outcomes) was the key factor of this association.

Housing was also a universal characteristic in the five deprivation indices in the introduction section, but this item was not considered in the surveys of the present thesis. Future research might put more emphasis on this aspect of deprivation. Family income was emphasized by both the Ghent deprivation atlas (2002) and the deprivation index of Child & family (2010). The present research could not unambiguously confirm the correlation between family income and oral health outcomes.

The two income-based determinants, increased allowance for health care interventions and the Maximum Bill measure, provided contradicting results in children and adults. While a strongly significant association was found between low-income children and all examined oral health outcomes, no relevant relationship could be found between adults with or without an increased allowance. The lack of convincing evidence can be mainly explained by the use of dichotomous scales, which are until present the only income-related determinants being systematically registered by the Belgian government and the Inter-mutualistic Agency (IMA). Based on the existence of a stepwise social gradient, the authors strongly recommend the use of standardized indices with more subscales, to improve both epidemiological research and policy interventions.

When high-risk groups are identified, another important question is ***how to reach them***. Although oral health inequalities are known for many years in many countries, few studies actually investigated on interventions with a measurable effect on oral health inequalities (**chapter III**). A literature review from the last ten years resulted in only 11 publications demonstrating measurable impacts on oral health inequalities. According to this review, population-based interventions were able to reduce the social gap between subgroups, only when they were applied automatically and mandatory to all, such as water fluoridation. On the contrary, when information or resources were offered within the population without obligation, oral health inequalities were widened, confirming the so-called "Matthew effect" (Perc, 2014).

As a reaction on the scarce number of studies describing measurable impacts on oral health inequalities, the present research was one of the first aiming to test the specific impact of a four-year longitudinal population-based intervention on oral health inequalities in primary school children (**chapter IV**). Although the oral health of primary school children in Flanders significantly improved between 2010 and 2014 and the intervention had a significant and durable positive impact on children's knowledge and the number of decayed teeth, inequalities remained statistically unchanged over the four years. Accordingly, the intervention did not reduce oral health inequalities, but did not widen them either. However, the high drop-out rates, especially in the lowest social class, can suggest a different impact in those who could not be surveyed over the four year period.

To tackle oral health disparities, a common-risk factor approach is recommended (Watt & Sheiham, 2012). Based on the fact that oral health inequalities are only one aspect of the entire spectrum of social inequalities in health, the present research set up an intervention to investigate the impact of community oral health workers (COHW's) (**chapter V**). Because of their experience with underprivileged individuals, the distance between these intermediary workers and the target population is supposed to be as short as possible. By providing an adequate educational program about oral health, the COHW's can determine enabling and disabling factors in both the target population and dental professionals, and try to reduce them. Furthermore, the intervention integrates the problem of oral health inequalities within a broader social approach. Greenberg *et al.* (2008) demonstrated the positive impact of dental case managers on access to oral health care services for low-income individuals. In addition to these earlier findings, the longitudinal survey which is presented in chapter V aims to lead to measurable and sustainable changes in oral health and oral health behaviour.

In the common-risk factor approach to oral health inequalities, it is important to recognise that focusing solely on oral health behaviour and oral health outcomes is only a symptomatic approach.

When unemployment is a social determinant of oral health, improving the oral health outcomes of unemployed individuals will only have a limited contribution to find a job (Glied & Neidell, 2010). Moreover, the chance that an oral health intervention will upgrade the educational level of adults might be very close to zero. The best strategy to avoid or reduce oral health inequalities, will be to avoid or reduce social inequalities in general (Marmot, 2010). For this reason, interventions should be implemented as concerted actions on both local, national and international level, including as many relevant partners as possible.

However, as long as social inequalities persist, dental practitioners should always be aware of this problem and recognise that some subgroups in society will need more intensive information and coaching. Oral health promotion should specifically put emphasis on the identified social risk groups, without denying the oral health needs of all members within the overall population. Actions should actively involve stakeholders, care providers and target population to obtain policy measures which are broadly supported. Prevention must be a key element in all strategies, since prevention early in life can avoid health problems later in life with an impact far beyond the oral health outcomes alone. For adults of all age groups, prevention is also important to prevent new cases of oral diseases (primary prevention) and to avoid deterioration of disease which is already present (secondary prevention).

By composing this doctoral thesis, the present research aimed to contribute to the global research on oral health inequalities. The epidemiological research, demonstrating the existence of oral health inequalities in Belgium and determining several social determinants of oral health, is illustrative but also confirmative in an international context. Inequalities have been reported in almost every country worldwide, often in much larger samples than those presented in **chapter I and II**. Nevertheless, it provides important information to local stakeholders, in order to improve oral health policies.

Chapter III and IV, have a more international character. First of all, **chapter III** reveals the lack of adequate research on the impact of interventions of any kind on oral health inequalities. Only one RCT met the inclusion criteria. Additionally, the study presented in **chapter IV** has a unique character, examining the impact of a four-year longitudinal RCT on oral health inequalities in a sample of primary school children. Although school programs and other preventive campaigns are frequently used in health policy, it is remarkable that the impact of these interventions on inequalities is so often overlooked. It is recommendable to pay more attention to this, by integrating it in effect and process evaluations.

Chapter V fits in the multidisciplinary approach of dealing with oral health inequalities, integrating community oral health workers (Benzian *et al.*, 2015; Watt *et al.*, 2015). The methodological article is the first step of a prospective longitudinal survey, aiming to improve oral health outcomes and oral health behaviour in socially vulnerable subpopulations in Flanders, and to provide new insights to international oral health research.

Limitations

The results of the present research need to be interpreted with caution, since methodological shortcomings and limitations can lead to misinterpretations.

A substantial limitation of this study might be **the risk of selection bias**. When emphasis is put on social inequalities, it is very challenging to obtain a representative sample, involving all underprivileged subgroups in society. In **chapter I, II and IV**, participants were recruited based on data of the National Register and information from the health insurance agencies. Although these databases provide complete information on all registered Belgian citizens, those who are not registered are completely denied. Undocumented migrants are not a marginal phenomenon in western societies. Their estimated number varies between 7 and 13% of the total number of immigrants with an official residence permit (Triandafyllidou, 2009). In Belgium, there were 1,214,605 legal immigrants on the 1st of January 2014, which means that the number of undocumented immigrants can be estimated between 85,000 and 160,000, corresponding to approximately 1% of the total Belgian population (Baeyens *et al.*, 2015). None of them were included in the present research, although they are a considerable and underprivileged subgroup.

Even when only officially registered Belgian residents are taken into consideration, it is possible that the study sample was not entirely representative for all social subgroups. Every scientific survey requires voluntary participation and written informed consent. The nationwide survey presented in **chapter II** reported a high proportion of refusals (48%). Although lack of interest was the main reason for refusal, it is possible that differences between responders and non-responders are present. During the process evaluation, dentist-interviewers indicated that the complex informed consent procedure was sometimes intimidating. This can be a barrier for individuals with lower health literacy or non-native speakers, although this needs further investigation.

Since similar sampling procedures were performed in **chapter I and IV**, the same remarks can be formulated. **Chapter IV** clearly showed higher drop-out rates for underprivileged individuals, possibly leading to bias. The proportion of low-income children in the intervention group was reduced from 21.3% at baseline to 11.0% after four years of follow-up, showing that these children were more likely to have missed at least one or more of the yearly examinations.

As a second shortcoming, the **definition of underprivileged individuals** requires further explanation. The Maximum Bill measure, which was used in **chapter I and IV**, is an indicator which is not purely income-based. The Maximum Bill system calculates for every individual a cost limit for medical care which is covered by the obligatory health insurance. Although the cost limit decreases stepwise with lower income scales, it is possible that children were not entitled to the Maximum Bill because of their low income, but because of high medical costs and both could not be distinguished. On the other hand, the causation and selection theory shows that health inequalities can be both a determinant and a consequence of financial hardship (Townsend & Davidson, 1982). In this respect, it is acceptable to use the Maximum Bill measure as a social indicator. Nevertheless, it also has clear limitations. As already mentioned, the variable can only be calculated for children who have a medical insurance, excluding undocumented migrants and residents who are not in line with the compulsory health insurance. Furthermore, the index can only be used to dichotomise the observed

sample in a group taking benefit from this measure and the others who did not. However, oral health inequalities are not binary, but appear in a social gradient (Sanders, 2006).

A similar social determinant was used in **chapter II**, in terms of being entitled to an increased allowance for health care interventions. In accordance with the Maximum Bill measure, this variable could only be determined for officially registered Belgian residents and its dichotomous character neglects the social gradient too. It is simply impossible to draw a single borderline between rich residents with standard health insurance coverage and poor residents receiving an increased reimbursement.

Another limitation is the **cross-sectional design** of the epidemiological data in **chapter I and II**. Although both chapters revealed significant associations between oral health outcomes and several social indicators, no information could be provided on the specific causes, mechanisms and barriers, both at supplier-side and user-side, which leaded to the observed oral health inequalities. Clearer insights in the reasons why some social subgroups in Belgium have poorer oral health outcomes can contribute to more adequate interventions, specifically targeting these barriers. Unfortunately, the present research could not provide this additional information.

The studies presented in **chapter I, II and IV** were based on **existing databases**. Although these databases were nationally representative and of considerable quality, they were not principally designed to examine oral health inequalities. As a consequence, underprivileged subgroups had lower absolute numbers, reducing the statistical power of the survey. In **chapter IV**, multivariate models could not provide statistical evidence to assume that the Glimlachen.be intervention had a different impact on children with different social status. These statistical analyses as such were not sufficient to draw conclusions, because lack of statistical significance could be due to smaller subgroups and lack of statistical power.

BROAD RELEVANCE OF THE WORK AND FUTURE PERSPECTIVES

Showing that oral health inequalities are an undeniable reality in Flanders is one of the most important results of the present research. Although the existing international literature already demonstrated the existence of a global social gap, it is important to discuss the particular context of Flanders, in order to provide specific insight to policy makers and stakeholders, to enhance oral health care and to reduce barriers and invoke enabling factors.

As a first item of relevance, the authors would like to stress the importance of high-quality and nationally representative epidemiological data. These data are not just a playground for researchers, but they enable policy makers to have an actual and detailed image of the oral health status of the population, and to identify high risk groups. Since the national government decided to abolish the nationwide oral health examination survey (**chapter II**), it will be impossible in the future to detect long-term evolutions in clinical oral health outcomes and oral health inequalities in Belgium. Given the high treatment need in the Flemish population in general and in underprivileged groups in particular, it is of high importance to continuously monitor the oral health status of the population, both for health care providers, stakeholders and policymakers.

Secondly, the results presented in **chapters I, II and IV** suggest that the existing governmental initiatives and oral health promotion campaigns could not eliminate oral health inequalities. Of course, a complete elimination of inequalities might be rather utopic, but significant progress can and should be made. To do so, the underlying mechanisms of oral health disparities should be discovered. It would be of particular interest to perform high-quality research on needs and enabling and disabling factors of underprivileged individuals. This research can be performed both in a sample of social workers and a sample of underprivileged individuals, in order to give a profound revision and reflection about the organisation of the Belgian oral health care system.

Chapter II showed that people cannot be simply divided into a group of “poor” and a group of “non-poor” to explain oral health inequalities. Indeed, no oral health differences could be found between those adults being eligible for an increased allowance, and the others. If this dichotomous family income scale would have been the only social determinant in the present survey, it would suggest the absence of oral health inequalities, which were, however, clearly demonstrated by other explanatory variables. Accordingly, the capacity of a dichotomous scale as social determinant is questionable, although it is still widely used as a standard in the Belgian oral health care organisation. When the annual family income is lower than €18,730.66, increased by €3,467.55 for every additional family member, a higher reimbursement of the standard care package is received, and a third-party payment can be applied. Unless in case of chronical illness, no further stratification is made between the richest Belgian resident and the individual with an annual income of just above the fixed limit. In this respect, the Maximum Bill has much more nuances, since the maximum limit of medical costs depends gradually on the family income, with 5 different subscales. According to the principle of proportionate universalism and the existing social gradient in oral health, it requires recommendation to consider the introduction of more step-wise scales in all aspects of oral health

care organisation and reimbursement systems, with more emphasis on a personalised preventive approach within subgroups.

Apart from financial aspects and reimbursement policy, proportionate universalism should also be considered in the field of oral health promotion. Although **chapter IV** showed significant improvements in the oral health status of a sample of primary school children over a four-year period, oral health inequalities remained unchanged, despite an oral health promotion program. These findings suggest targeted interventions, instead of a population-based approach. Children eligible for the Maximum Bill are determined as a possible target group (**chapter I and IV**), but there must be others beyond the present findings. Regarding adults, **chapter II** showed that individuals with lower educational level, unemployed participants and those with a non-western nationality had more untreated tooth decay. So, oral health promotion should pay special attention to these subgroups in future campaigns. Again, this does not mean that oral health promotion should focus exclusively on these subgroups, but more stratified and intensified within high-risk groups.

In the present research, dealing with the issue of oral health inequalities, most emphasis was put on the oral health status and oral health needs of underprivileged individuals and their environment. However, there is one partner who remains underexposed in this story: the **dental practitioner**. An important aim for future research is to explore existing barriers and needs within dental professionals, contributing to oral health inequalities. Indeed, these inequalities are not simply caused by a care demand of vulnerable subgroups which remains unanswered by the dental professional. Provision of oral health care is a complex interplay between care demanders and care providers, within a legislative context with opportunities and restrictions. Both sides have rights and obligations, and all perceived problems should be examined profoundly, in order to create a balanced symbiosis.

An important challenge in this respect is to deal with the decreasing and ageing population of general dentists in Flanders, containing a possible risk for vulnerable subgroups. According to the high demand and the limited supply, it is comprehensible if dental practitioners prefer to spend their time at compliant patients with little additional concerns. For this reasons, structural solutions need to be found to make the choice of treating vulnerable patients an easy choice, both in terms of administration and practical circumstances. The involvement of oral hygienists in the Belgian oral health care system can be an important element to further investigate. Additionally, a promising research field is opened by introducing “community health workers” (COHW’s). These experts by experience give assistance within socially deprived communities, to reduce barriers and misunderstandings between care demanders and care providers.

SUMMARY

International literature demonstrates an unequal distribution of oral diseases in society. A social gradient is observed, in which the most underprivileged individuals have the worst oral health status. Profound scientific research on these social inequalities on a national level is rather scarce. However, it can be expected that social disparities in oral health are also present in Belgium.

The central theme of this thesis was to investigate social inequalities in oral health in Belgium and the possible effects of interventions on the reduction of these inequalities.

The Belgian situation was demonstrated by means of two nationally representative cross-sectional epidemiological surveys (**chapter I and II**). **Chapter I** focussed on children in the last year of primary school (mean age 11.25; SD=0.68). In this sample (n=2,216), those who were entitled to the Maximum Bill measure had significantly worse outcomes than the other children. Both untreated tooth decay and level of care were associated with children's social status. Furthermore, clear social differences were found in oral health behaviour, assessed by means of the mean plaque score and the frequency of dental visits. Only half of the Maximum Bill children could be considered as regular dental attenders, whereas 12.6% of them did not have any dental visit in the five years prior to the survey. In the other children, this was 3.4%.

In **chapter II**, data from the Belgian Oral Health Data Registration and Evaluation System (2009-2010) were used, combining a health examination survey with a health interview survey. For univariate and multivariate statistical analyses of socio-economic oral health disparities, only the economically active population was included (n=1,215). These analyses showed that employment status and educational attainment were more important determinants than family income. Participants with higher education had lower DMFT scores than those with primary education or no diploma. Employment was associated with the occurrence of untreated tooth decay, especially in the youngest age group. Unemployed women had a higher risk of complete edentulousness. Apart from social determinants, frequency of toothbrushing and plaque scores had an important role in the presence of untreated tooth decay.

Table S1 provides a summary of the different social determinants which were identified as factors associated with deprived oral health.

Social subgroup with significantly worsened oral health outcomes	Oral health outcome variable	Referring chapter
Children		Chapter I
Being entitled to Maximum Bill	Mean plaque index	
	D_1MFT, D_3MFT, D_1MFS, D_3MFS	
	Care Index (CI), Treatment Index (TI), Restorative Index (RI)	
	Knowledge score	
	Attitude score	
	CI100%, TI100%, RI100%	
	No regular dental attendance	
	No dental visit between 2009 and 2013	
	Caries-free proportion	
Adults		Chapter II
Being unemployed	Untreated tooth decay[a]	
	Edentulousness[b]	
Having a non-Western nationality	D_3MFT	
	Untreated tooth decay	
Having a non-Western country of birth	D_3MFT	
	Untreated tooth decay	
Having a lower secondary school degree	Untreated tooth decay	
	Edentulousness	

Table S1: List of social subgroups showing poorer oral health outcomes within the present research

a: especially within the youngest age group (<25y)

b: especially within women

Chapter III describes a literature review searching interventions (2008-2017) with a measurable impact on oral health inequalities. Only 11 publications met the inclusion criteria. Among this limited number of studies with rather moderate quality, six interventions with a positive effect on social disparities were found. Interventions on population-level seemed to have a positive effect on the reduction of social disparities, only when they were automatically applied or had an obligatory character (e.g. water fluoridation).

Chapter IV investigated the impact of a 4-year health promotion program (Glimlachen.be), which was conducted between 2010 and 2014 within 1,058 primary schoolchildren. During this program, Belgian schools were visited yearly with a mobile dental unit. Every year, a different oral health issue was highlighted and didactic tools were provided to the school and the teachers. Multivariate mixed-model analyses were performed to investigate the overall effect of the intervention on oral health and oral health behaviour, comparing the intervention group with two cross-sectional control groups at baseline and after 4 years. Based on the scarcity of scientific research demonstrated in **chapter III**, the present research also observed the impact of the school program on social inequalities in oral health. Within the intervention group, children entitled to the Maximum Bill measure were compared with the other children.

The oral health status of both intervention and control group improved significantly over the four year period. Statistical analyses demonstrated that the intervention had a significant and durable

impact on the number of decayed teeth and children's knowledge scores. Regarding the impact on social inequalities, the intervention seemed not to have a statistically significantly different effect on the two social subgroups. Both before and after the intervention, clear social disparities were present. Although no increase of the social gap could be demonstrated, special attention needs to be paid to the high drop-out rate within the children of lower social status, possibly leading to bias.

Finally (**chapter V**), a protocol was proposed to execute an intervention study targeting underprivileged households. As part of the intervention, these families are supported in their preventive and curative oral health care path by a Community Oral Health Worker (COHW). This COHW is experienced with the environment of underprivileged individuals. After a two-day educational program, the COHW acts as an intermediary worker between the underprivileged individuals and the dental professional, and helps to optimise the individual oral health. The most important objective is to (re)integrate socially vulnerable individuals in regular oral health care, by reducing existing barriers and stimulating enabling factors in both underprivileged individuals and dental professionals.

The intervention, named "Ieders Mond Gezond" ("Healthy Mouth for All"), was piloted in 4 Flemish cities. In this pilot study, the educational program and the further intervention protocol was optimised. In a second phase, the long-term effects on oral health, oral health behaviour and access to care will be measured after a two-year cluster-randomised controlled trial in Flanders. In this longitudinal study, all Flemish communities having a deprivation index >10% are clustered in 8 zones, randomly selected in 6 intervention and 2 control zones. In every intervention zone, a two-day educational program for COHW's will be organised, targeting voluntary or professional workers of poverty and welfare organisations. After the educational program, these COHW's will be involved in supporting their target group, at a ratio of 15 per COHW. In the control zones, a clinical oral health examination with referral letter will be executed yearly. The effects of the intervention will be evaluated both quantitatively and qualitatively.

This doctoral thesis ends with a call for further research. It shows that socio-economic inequalities in oral health persist in Belgian children and adults, despite all existing policy measures. The present research identifies several social determinants, on which emphasis should be put in future interventions. Although, these interventions should take into consideration the social gradient, leading to stepwise deterioration of oral health outcomes. Until present, international literature does not provide sufficient solutions to deal with these inequalities.

SAMENVATTING

De internationale literatuur toont aan dat mondaandoeningen ongelijk verdeeld zijn over de bevolking. Een sociale gradiënt is merkbaar, waarbij personen met de laagste sociaaleconomische status de slechtste mondgezondheid vertonen. Diepgaand wetenschappelijk onderzoek naar deze sociale ongelijkheden op nationaal niveau is eerder schaars. Toch kunnen deze sociale ongelijkheden met betrekking tot de mondgezondheid ook in België verwacht worden.

Het centrale thema van dit proefschrift was het onderzoek naar sociale ongelijkheden in mondgezondheid in België en het mogelijke effect van interventies om deze ongelijkheden te reduceren.

De Belgische situatie werd in kaart gebracht door middel van twee nationaal representatieve dwarsdoorsnede epidemiologische studies (hoofdstuk I en II). **Hoofdstuk I** focuste op kinderen uit het laatste jaar van het lager onderwijs (gemiddelde leeftijd 11.25; SD=0.68). Bij de lagere schoolkinderen (n=2,216) scoorden zij die in aanmerking kwamen voor de maximumfactuur significant slechter dan de andere kinderen. Zowel het voorkomen van tandbederf als de verzorgingsgraad bleken geassocieerd met de sociale status van de kinderen. Hiernaast werden ook duidelijke sociale verschillen vastgesteld in het mondgezondheidsgedrag, gemeten door middel van de gemiddelde plaquescore en de frequentie van tandartsbezoeken. Slechts de helft van de kinderen die in aanmerking kwamen voor de maximumfactuur konden beschouwd worden als regelmatige tandartsbezoekers, terwijl 12.6% van hen geen enkel tandartsbezoek had gedurende de vijf jaar voorafgaand aan het onderzoek. Bij de andere kinderen was dit 3.4%.

In **hoofdstuk II** werden data geanalyseerd uit de nationale dataregistratie (2009-2010), waarbij een klinisch mondonderzoek werd gekoppeld aan het invullen van een gevalideerde vragenlijst. Voor het uni- en multivariaat onderzoek naar socio-economische verschillen in mondgezondheid werd enkel de economisch actieve bevolking geïncludeerd (n=1,215). Hieruit bleek dat tewerkstelling en opleidingsniveau belangrijkere indicatoren waren dan het gezinsinkomen. Hoogopgeleide deelnemers hadden een lagere DMFT-score dan diegenen met enkel een diploma lager onderwijs of zonder diploma. Tewerkstelling was geassocieerd met het voorkomen van onbehandeld tandbederf, vooral in de jongste leeftijdsgroep. Verder hadden werkloze vrouwen een hoger risico op volledige tandenloosheid. Naast sociale determinanten hadden ook de poetsfrequentie en de plaquescores een belangrijke rol bij het vaststellen van onbehandeld tandbederf.

Tabel S1 geeft een samenvatting van de verschillende sociale determinanten die in dit onderzoek werden geïdentificeerd als factoren geassocieerd met een slechtere mondgezondheid.

Subgroepen in de samenleving met een significant slechtere mondgezondheid	Uitkomstvariabelen	Hoofdstuk
Kinderen		HI
In aanmerking voor de maximumfactuur	Gemiddelde plaque score	
	D_1MFT, D_3MFT, D_1MFS, D_3MFS	
	Care Index (CI), Treatment Index (TI), Restorative Index (RI)	
	Kennis score	
	Attitude score	
	CI100%, TI100%, RI100%	
	Geen regelmatige tandartsbezoeker	
	Geen tandartsbezoek tussen 2009 en 2013	
	Cariësvrije proportie	
Volwassenen		HII
Werklozen	Onbehandeld tandbederf [a]	
	Tandenloosheid [b]	
Niet-Westerse nationaliteit	D_3MFT	
	Onbehandeld tandbederf	
Niet-Westers geboorteland	D_3MFT	
	Onbehandeld tandbederf	
Diploma lager secundair als hoogste diploma	Onbehandeld tandbederf	
	Tandenloosheid	

Tabel S1: Lijst van sociale determinanten die binnen dit onderzoek geassocieerd bleken met een slechtere mondgezondheid, en de specifieke uitkomstvariabelen

a: vooral binnen de jongste leeftijdscategorie (<25j)

b: vooral bij vrouwen

Het **derde hoofdstuk** betreft een literatuurreview waarbij gezocht werd naar interventies (2008-2017) met een meetbaar effect op sociale ongelijkheden in mondgezondheid. Slechts 11 publicaties voldeden aan deze voorwaarden. Binnen dit gering aantal studies met eerder matige kwaliteit, werden zes interventies gevonden met een positief effect op sociale ongelijkheden. Interventies op populatieniveau bleken hierbij enkel een positief effect te hebben op het reduceren van de sociale ongelijkheid met betrekking tot mondgezondheid wanneer zij een automatisch of verplicht karakter hadden, zoals bij waterfluoridering.

In **hoofdstuk IV** werd de impact onderzocht van een 4-jarig voorlichtingsprogramma (Glimlachen.be) dat werd uitgevoerd tussen 2010 en 2014 bij 1,058 lagere schoolkinderen. Tijdens dit programma werden Belgische scholen jaarlijks bezocht met een tandmobiel, en werd per jaar gewerkt rond een nieuw thema met betrekking tot mondgezondheid, waarbij didactisch materiaal aan de school en de leerkracht ter beschikking werd gesteld. Door middel van multivariaat gemengd-model analyses werden de algemene effecten van de interventie onderzocht op mondgezondheid en mondgezondheidsgedrag, vergeleken met twee dwarsdoorsnede controlegroepen op baseline niveau en na 4 jaar interventie. Vertrekkend vanuit de schaarste aan wettenschappelijk onderzoek in **hoofdstuk III** werd eveneens de impact van het schoolprogramma op de sociale ongelijkheden

onderzocht, door binnen de interventiegroep kinderen die in aanmerking kwamen voor de maximumfactuur te vergelijken met de andere kinderen.

Bij alle kinderen ging de mondgezondheid er over de onderzoeksperiode van vier jaar significant op vooruit. De statistische analyses toonden aan dat de interventie op zich een significant en duurzaam positief effect had op het aantal tanden met tandbederf en op de kennis van de kinderen. Wat betreft de invloed op sociale ongelijkheden, bleek de interventie statistisch gezien geen verschillende impact te hebben gehad op de twee sociale subgroepen. Zowel voor als na de interventie bleven duidelijke sociale ongelijkheden meetbaar. Ondanks het feit dat er geen toename van de sociale kloof kon worden aangetoond, dient toch de nodige aandacht besteed te worden aan de hoge uitval tijdens de studie van kinderen met een lagere sociale status, met invloed op de eindresultaten.

Tot slot (**hoofdstuk V**) werd een protocol voorgesteld voor het uitvoeren van een interventiestudie die zich richt op gezinnen in kansarmoede. Als deel van de interventie worden deze gezinnen in hun preventief en curatief zorgtraject ondersteund en begeleid door een Community Oral Health Worker (COHW). Deze COHW is een persoon met ervaring in de leefwereld van personen in kansarmoede. Na het volgen van een tweedaagse opleiding dient de COHW een brugfunctie te vervullen tussen de personen in kansarmoede en de tandarts. Hij/zij dient ook mee in te staan voor het optimaliseren van de individuele mondgezondheid. De belangrijkste doelstelling is het (her)integreren van sociaal kwetsbare personen in de reguliere eerstelijnszorg, door het wegnemen van barrières en het ondersteunen van zowel de personen in kansarmoede als van de tandarts.

De interventie, die de naam “Ieders Mond Gezond” kreeg, werd voorafgaand aan dit uit te voeren onderzoek uitgevoerd tijdens een pilootproject in 4 Vlaamse steden. Hierbij werden de opleidingsmodule en het verdere interventieprotocol geoptimaliseerd. In een tweede fase zullen de lange termijneffecten gemeten worden op de mondgezondheid, het mondgezondheidsgedrag en de zorgtoegankelijkheid van de doelgroep tijdens een tweejarig cluster gerandomiseerd en gecontroleerd onderzoek in heel Vlaanderen. In dit longitudinaal onderzoek worden alle Vlaamse gemeenten met een kansarmoede-index hoger dan 10% geclusterd in 8 zones, en nadien verdeeld in 6 interventiezones en 2 controlezones. In elke interventiezone zal een tweedaagse opleiding tot COHW georganiseerd worden, waarvoor vrijwilligers of professionele medewerkers van alle armoede- en welzijnsorganisaties zich kunnen inschrijven. Nadien zullen deze COHW’s ingezet worden bij het begeleiden van hun doelgroep, aan een ratio van 15 personen per COHW. In de controlezones zal enkel een jaarlijks klinisch mondonderzoek uitgevoerd worden met het meegeven van een verwijsbrief voor de tandarts. De effecten van de interventie zullen zowel kwantitatief als kwalitatief geëvalueerd worden.

Dit proefschrift eindigt dus met een aanzet tot het uitvoeren van verder onderzoek. Er wordt ook aangetoond dat, ondanks alle bestaande beleidsinitiatieven, socio-economische verschillen blijven bestaan bij Belgische kinderen en volwassenen. Binnen dit onderzoek worden verschillende sociale determinanten geïdentificeerd, waar toekomstige interventies zich extra kunnen op richten. Interventies dienen hierbij echter steeds rekening te houden met de sociale gradiënt, waarbij mondgezondheidsproblemen trapsgewijs voorkomen. Tot op vandaag biedt de internationale literatuur nog te weinig concrete antwoorden om deze ongelijkheden het hoofd te bieden.

ACKNOWLEDGEMENTS

International literature describes the positive effect of individuals' social network on oral health, oral health behaviour and oral health inequalities. Although there might be no randomised controlled trial to prove it, I am absolutely convinced that this 'social capital' also has a massive influence on the developmental process of a doctoral thesis. The conclusion is firm: Not a single word of this manuscript could be written down without the indispensable help of a solid network of competent colleagues, wise mentors and loving relatives and friends, supporting me for many years.

First of all, I would like to express my sincere gratitude towards Prof. Dr. Luc De Visschere for giving me this opportunity. Your unfaltering belief in my competences stimulated me to perseverate until the end. We know each other for many years, and a respectful professional relationship became a close friendship. You know my strengths and my weaknesses, and protected me against obstacles and against my own unlimited and sometimes harmful enthusiasm. We are very complementary, and this well-oiled tandem was the best preparation I could ever have. You are one of the most emotionally stable persons I ever met, and although you're not tall either, you are a rock to build on.

Next, special thanks to Prof. Dr. Luc Martens, co-promotor of this doctoral thesis and promotor of my master thesis. You know I respect both your professional career and your personality. You prove every day that being courteous and mild is not a barrier to reach the highest goals in your career. We both share the love for art and rhetoric, although my long and wordy writings often needed some cutting work. It was a pleasure to exchange ideas and to work together on both my master thesis and my doctoral thesis. With a smile, I will always remember one of your favourite quotes: "*Martijn, I appreciate your enthusiasm, but this is a scientific publication, and no prose…*".

Special and infinite gratefulness to Prof. em. Dr. Jacques -'Jackie'- Vanobbergen. You stand by my side from the very beginning, literally at the baptistery. My life course and professional life, as well as my second name, would not have been the same without you. You sowed in me the germ of an unstoppable drive to stand up for the most vulnerable, and to strive for equity in general, and equity in oral health in particular. Your career is phenomenal, so it is both an honour and a big challenge to follow in your footsteps. Some people call me 'Jackie junior', a title which I will carry with pride.

Besides my advisory mentors, I would like to thank the examination committee, chaired by Prof. Dr. Koen Van Herck. I am grateful to mention Prof. Dr. Peter Bottenberg, Prof. Dr. Mieke De Bruyne, Prof. Dr. Stéphanie De Maesschalck, Dr. Georgios Tsakos and Prof. Dr. Linda Van Den Berghe. Your comments and questions put the finger on shortcomings and limitations of my own work, and so broadened my knowledge and skills. Your suggestions and additional input improved the quality of this final manuscript.

The department of Community Dentistry and Oral Public Health is a cheerful and enthusiast team of motivated and passionate people. Working in such an atmosphere was wonderful and made me feel at home. Thanks Griet, Ellen, Lynn, Inès, Hilde and the colleagues of Gerodent for your essential contribution to the work of our beautiful department. I also want to acknowledge all my colleagues from CEMOB in Ledeberg. Special thanks to Sara, my colleague in Wingene, who gives me the ideal working conditions and individual freedom to combine the work as a private dentist with the unpredictable live in the academic world. And when I sometime suffer from work overload, there is always her extremely cute little son, Cyriel, to make me smile again.

During the creation process of this doctoral thesis, I had the privilege to meet and work together with dedicated and interesting people, in the academic world and many other organisations. I want to thank the Ministry of Welfare, Public Health and Family, and the dental professional organisations VVT (Verbond der Vlaamse Tandartsen) and VBT (Vlaamse Beroepsvereniging Tandartsen) for their contribution to oral health care for all citizens and their special interest in oral health promotion and prevention. Thanks to all partners within the Flemish Institute 'GezondeMond', chaired by Mr. Jean-Paul Souffriau. I also have the deepest respect for our colleagues from the KU Leuven, in particular towards Prof. Dr. Dominique Declercq and Prof. Dr. Joke Duyck, who made a great impression on me with their intelligence and personality. I also want to express my gratitude to all people I met in the context of 'Ieders Mond Gezond', the oral health coaching program for underprivileged families. This project would not have been possible without the commitment and support from all of you. You are pioneers in oral health equity. Many thanks to Rudi Verbeeck and Els Mostien, my personal heroes, who both did an incredible job on the field and form the most efficient tandem I've ever seen.

Off course, not a single thing would be possible without the support of my parents. They gave me life, education and love from my first day on earth. I had the privilege to grow up in a warm and loving family, together with my lovely sisters Lien and Marie. We all received the intellectual capacities and support to study and to explore our talents, a precious gift making us more fortunate than most of the children worldwide. I am grateful and proud of the Christian education you gave me. We learned that it is more important to give than to get. With this background I entered university and I hope this fundamental attitude will never change. I hope I will always stay the same Martijn, the hyperkinetic social kid, sometimes a bit weird and unconventional, but always with the best intentions. The university setting is a wonderful place to work in, but the pressure of publishing and the internal competition contain the risk of working in function of a personal career, instead of contributing to a better society and high-quality evidence-based dentistry. I sincerely hope to always have people around me to help me keeping my feet on the ground.

I also want to dedicate this thesis to Dr. Julien De Clercq, a personal friend and mentor, who passed away on the day I finished the first version of this thesis. I hope he would have been proud to read this final version.

Last but not least, I want to thank you, Fien, always there to support me when I need you. You know what work is all about, you know what life is all about, and you know what love is all about. I am a big supporter of equal rights for men and women, so it is good now to have the same title as you, dr. Van Maldergem. Today, your name is written in this book, but more important is that it was and stays written in my heart.

To all you others, friends and colleagues, from inside or outside the P8 building, thank you all. I cannot mention you all personally in this acknowledgements section -this book is more than long enough, you can ask Prof. Martens to confirm it- but I will certainly give you a warmly smile every time we'll meet again.

BIBLIOGRAPHY

Acharya S (2008): Factors affecting dental anxiety and beliefs in an Indian population. Journal of Oral Rehabilitation. 35(4), 259–267. doi:10.1111/j.1365-2842.2007.01777.x.

Achembong LN, Kranz AM, Rozier RG (2014): Office-Based Preventive Dental Program and Statewide Trends in Dental Caries. Pediatrics. 133(4), 827-834. doi:10.1542/peds.2013-2561.

Ajayi DM, Arigbede AO (2012): Barriers to oral health care utilisation in Ibadan, South West Nigeria. African Health Sciences. 12(4), 507-513.

Almonaitiene R, Balciuniene I, Tutkuviene J (2010): Factors influencing permanent teeth eruption. Part one--general factors. Stomatologija. 12(3), 67-72.

Asimakopolou K, Newton JT (2015): The contributions of behaviour change science towards dental public health practice: a new paradigm. Community Dentistry and Oral Epidemiology. 43(1), 2-8.

Auluck A, Walker BB, Hislop G , Lear SA, Schuurman N, Rosin M (2016): Socio-economic deprivation: a significant determinant affecting stage of oral cancer diagnosis and survival. BMC Cancer. 16, 569. doi:10.1186/s12885-016-2579-4.

Awano S, Ansai T, Takata Y, Soh I, Akifusa S, Hamasaki T, Yoshida A, Sonoki K, Fujisawa K, Takehara T (2008): Oral health and mortality risk from pneumonia in the elderly. Journal of Dental Research. 87(4), 334-339.

Badri P, Saltaji H, Flores-Mir C, Amin M (2014): Factors affecting children's adherence to regular dental attendance: a systematic review. Journal of the American Dental Association. 145(8), 817-828. doi: 10.14219/jada.2014.49.

Baeyens P, Beys M, Bourguignon M, Büchler A, De Smet F, Dewulf K, et al (2015): Migration en droits et en chiffres 2015-Migratie in cijfers en in rechten 2015. Available from: http://www.myria.be/nl/publicaties/migratie-in-cijfers-en-in-rechten- 2015.

Bahekar AA, Singh S, Saha S, Molnar J, Arora R (2007): The prevalence and incidence of coronary heart disease is significantly increased in periodontitis: a meta-analysis. American Heart Journal. 154(5), 830-837.

Bandura A (1977): Self-efficacy: towards a unifying theory of behaviour change. Psychological Review. 84, 191-215.

Barker DJ, Osmond C, Forsen TJ, Kajantie E, Eriksson JG (2005): Trajectories of growth among children who have coronary events as adults. The New England Journal of Medicine. 353(17), 1802-1809.

Bateson P, Barker D, Clutton-Brock T, Deb D, D'Udine B, Foley RA, Gluckman P, Godfrey K, Kirkwood T, Lahr MM, et al. (2004): Developmental plasticity and human health. Nature. 430(6998), 419-421.

Bedos C, Loignon C, Landry A, Richard L, Allison PJ (2014): Providing care to people on social assistance: how dentists in Montreal, Canada, respond to organisational, biomedical, and financial challenges. BMC Health Service Research. 14, 472. doi:10.1186/1472-6963-14-472.

Benzian H, Greenspan JS, Barrow J, Hutter JW, Loomer PM, Stauf N, Perry DA (2015): A competency matrix for global oral health. Journal of Dental Education. 79(4), 353-361.

Berglund E, Westerling R, Lytsy P (2017): Social and health-related factors associated with refraining from seeking dental care: A cross-sectional population study. Community Dentistry and Oral Epidemiology. 45(3), 258-265

Berkman ND, Sheridan SL, Donahue KE, Halpern DJ, Crotty K (2011): Low health literacy and health outcomes: an updated systematic review. Annals of Internal Medicine. 155(2), 97-107. doi:10.7326/0003-4819-155-2-201107190-00005.

Bernabe E, Stansfeld SA, Marcenes W (2011): Roles of Different Sources of Social Support on Caries Experience and Caries Increment in Adolescents of East London. Caries Research. 45(4), 400-407.

Bisgaier J, Cutts DB, Edelstein BL, Rhodes KV (2011): Disparities in child access to emergency care for acute oral injury. Pediatrics. 127(6), 1428-1435. doi: 10.1542/peds.2011-0011.

Blinkhorn F, Brown N, Freeman R, Humphris G, Martin A, Blinkhorn A (2012) A phase II clinical trial of a dental health education program delivered by aboriginal health workers to prevent early childhood caries. BMC Public Health. 12, 681. doi:10.1186/1471-2458-12-681.

Bonetti D, Clarkson JE (2016): Fluoride Varnish for Caries Prevention: Efficacy and Implementation. Caries Research. 50(suppl 1), 45-49.

Brocklehurst P, Price J, Glenny AM, Tickle M, Birch S, Mertz E, Grytten J (2013): The effect of different methods of remuneration on the behaviour of primary care dentists. Cochrane Database of Systematic Reviews. (11):CD009853. doi: 10.1002/14651858.CD009853.pub2.

Broughton JR, Maipi JT, Person M, Thomson WM, Morgaine KC, Tiakiwai SJ, Kilgour J, Berryman K, Lawrence HP, Jamieson LM (2013). Reducing disease burden and health inequalities arising from chronic disease among indigenous children: an early childhood caries intervention in Aotearoa/New Zealand. BMC Public Health. 13, 1177. doi: 10.1186/1471-2458-13-1177.

Campbell FA, Ramey CT (1994): Effects of early intervention on intellectual and academic achievement: a follow-up study of children from low-income families. Child Development. 65(2), 684-698.

Carey G, Crammond B, De Leeuw E (2015): Towards health equity: a framework for the application of proportionate universalism. International Journal for Equity in Health. 14, 81. doi:10.1186/s12939-015-0207-6.

Carstairs V, Morris R (1991) Deprivation and health in Scotland. Aberdeen: Aberdeen University Press. 0080379796.

Carvalho TS, Lussi A, Jaeggi T, Gambon DL (2014): Erosive tooth wear in children. Monographs in Oral Science. 25, 262-278. doi: 10.1159/000360712.

Castilho AR, Mialhe FL, Barbosa T de S, Puppin-Rontani RM (2013): Influence of family environment on children's oral health: a systematic review. Jornal de Pediatria. 89(2), 116−123.

Celeste RK, Nadanovsky P (2010): How much of the income inequality effect can be explained by public policy? Evidence from oral health in Brazil. Health Policy. 97, 250–258.

Chaves SC, Vieira-da-Silva LM (2002): Anticaries effectiveness of fluoride toothpaste: a meta-analysis. Revista De Saude Publica. 36(5), 598-606.

Claessens P, De Visschere L (2009): PWO 2009. De ontwikkeling van een Evidence Based Educatiemodule Mondzorg en het effect op de kennis en attitude van studenten verpleegkunde).

Cohen-Carneiro F, Souza-Santos R, Rebelo MA (2011): Quality of life related to oral health: contribution from social factors. Ciencia & Saude Coletiva. 16(Suppl 1), 1007-1015.

Colborn T (2004): Neurodevelopment and endocrine disruption. Environmental Health Perspectives. 112(9), 944-949.

Colley JR, Douglas JW, Reid DD (1973): Respiratory disease in young adults: influence of early childhood lower respiratory tract illness, social class, air pollution, and smoking. British Medical Journal. 3(5873), 195-198

Conway DI, Brenner DR, McMahon AD, Macpherson L, Agudo A, Ahrens W, Bosetti C, Brenner H, Castellsague X, Chen C, et al. (2015): Estimating and explaining the effect of education and income on head and neck cancer risk: INHANCE consortium pooled analysis of 31 case-control studies from 27 countries. International Journal of Cancer. 136(5), 1125-1139. doi:10.1002/ijc.29063.

Coppieters Y, Piette D, Kohn L, De Smet P (2002) Health inequalities: self-reported complaints and their predictors in pupils from Belgium. Revue d'Epidémiologie et de Santé Publique. 50(2), 135-146.

Costa SM, Martins CC, Bonfim ML, Zina LG, Paiva SM, Pordeus IA, Abreu MH (2012): A systematic review of socio-economic indicators and dental caries in adults. International Journal of Environmental Research and Public Health. 9, 3540-3574.

Costa SM, Abreu MH, Vasconcelos M, Lima Rde C, Verdi M, Ferreira EF (2013): Inequalities in the distribution of dental caries in Brazil: a bioethical approach. Ciencia & Saude Coletiva. 18(2), 461-470.

Cunha-Cruz J, Milgrom P, Shirtcliff RM, Bailit HL, Huebner CE, Conrad D, Ludwig S, Mitchell M, Dysert J, Allen G, et al. (2015): Population-centered Risk- and Evidence-based Dental Interprofessional Care Team (PREDICT): study protocol for a randomized controlled trial. Trials. 16, 278. doi:10.1186/s13063-015-0786-y.

Da Fonseca (2012): The Effects of Poverty on Children's Development and Oral Health. Pediatric Dentistry. 34(1), 32-38.

Davis MM, Hilton TJ, Benson S, Schott J, Howard A, McGinnis P, Fagnan L (2010): Unmet dental needs in rural primary care: a clinic-, community-, and practice-based research network collaborative. The Journal of the American Board of Family Medicine. 23(4), 514-522.

Declerck D, Leroy R, Martens L, Lesaffre E, Garcia-Zattera MJ, Vanden Broucke S, Debyser M, Hoppenbrouwers K (2008): Factors associated with prevalence and severity of caries experience in preschool children. Community Dentistry and Oral Epidemiology. 36, 168-178. doi:10.1111/j.1600-0528.2007.00385.x.

Declerck D, Bottenberg P, Carvalho J, Declerck C, De Vos E, Vanden Abbeele A, Van Nieuwenhuysen JP, Vanobbergen J, Bogaerts K (2013): Development and Implementation of an Oral Health Data Registration and Evaluation System for the Belgian Population. Journal of Dental, Oral and Craniofacial Epidemiology. 1(3), 45-54.

De Coen V, Vansteelandt S, Maes L, Huybrechts I, De Bourdeaudhuij I, Vereecken C (2012): Parental socio-economic status and soft drink consumption of the child. The mediating proportion of parenting practices. Appetite. 59, 76–80.

De Reu G, Vanobbergen J, Martens L (2008): The influence of social indices on oral health and oral health behaviour in socially deprived. Community Dental Health. 25(1), 33-37.

Do LG (2012): Distribution of Caries in children: variations between and within populations. Journal of Dental Research. 91(6), 536-543.

Do LG, Scott JA, Thomson WM, Stamm JW, Rugg-Gunn AJ, Levy SM, Wong C, Devenish G, Ha DH, Spencer AJ (2014): Common risk factor approach to address socio-economic inequality in the oral health of preschool children – a prospective cohort study. BMC Public Health. 14, 429.

Douglass JM, Li Y, Tinanoff N (2008): Association of mutans streptococci between caregivers and their children. Pediatric Dentistry. 30(5), 375-387.

Duijster D, O'Malley L, Elison S, Van Loveren C, Marcenes W, Adair PM, Pine CM (2013): Family relationships as an explanatory variable in childhood dentalcaries: a systematic review of measures. Caries Research. 47(1), 22-39. doi:10.1159/000351832.

Edelstein BL (2005): Pediatric caries worldwide: implications for oral hygiene products. Compendium of Continuing Education in Dentistry. 26(5 Suppl 1), 4-9.

Egbor PE, Akpata O (2014): An evaluation of the sociodemographic determinants of dental anxiety in patients scheduled for intra-alveolar extraction. Libyan Journal of Medicine. 9, 25433. doi:10.3402/ljm.v9.25433.

Ferlay J, Soerjomataram I, Dikshit R, Eser S, Mathers C, Rebelo M, Parkin DM, Forman D, Bray F (2015): Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. International Journal of Cancer. 136(5), 359–386. doi:10.1002/ijc.29210.

Gabardo MC, Moysés ST, Moysés SJ (2013): Self-rating of oral health according to the Oral Health Impact Profile and associated factors: a systematic review. Pan American Journal of Public Health. 33(6), 439-445.

Gao XL, McGrath C (2011): A review on the oral health impacts of acculturation. Journal of Immigrant and Minority Health. 13(2), 202-213. doi:10.1007/s10903-010-9414-9.

Gini C (1936): On the Measure of Concentration with special reference to income and statistics. Colorado College Publication. 208, 73-79.

Glied S, Neidell M (2010): The economic value of teeth. The Journal of Human Resources. 45(2), 468–96.

Glimlachen.be. (2014). Glimlachen Wetenschappelijk Rapport. [Internet] Available from: http://www.glimlachen.be/library/207/files/Wetenschappelijk_rapport_Prof_Dr_Vanobbergen_met_IMA-20150414-1145.pdf [Accessed 14 Apr. 2015].

Gomaa N, Glogauer M, Tenenbaum H, Siddiqi A, Quiñonez C (2016): Social-Biological Interactions in Oral Disease: A 'Cells to Society' View. PLOS One. 11(1), e0146218. doi:10.1371/journal.pone.0146218.

Greenberg BJS, Kumar JV, Stevenson H (2008): Dental case management - Increasing access to oral health care for families and children with low incomes. Journal of the American Dental Association. 139(8), 1114-1121.

Grytten J (2017): Payment systems and incentives in dentistry. Community Dentistry and Oral Epidemiology. 45:1-11.

Hagedoorn P, Vandenheede H, Vanthomme K, Willaert D, Gadeyne S (2016): A cohort study into head and neck cancer mortality in Belgium (2001-11): Are individual socio-economic differences conditional on area deprivation? Oral Oncology. 61, 76-82. doi:10.1016/j.oraloncology.2016.08.014.

Hakeberg M, Wide Boman U (2017): Dental care attendance and refrainment from dental care among adults. Acta Odontologica Scandinavica. 75(5), 366-371.

Hamermesh DS, Biddle JE (1994): Beauty and the labor market. American Economic Review. 84(5), 1174.

Hatch EE, Palmer JR, Titus-Ernstoff L, Noller KL, Kaufman RH, Mittendorf R, Robboy SJ, Hyer M, Cowan CM, Adam E, et al. (1998): Cancer risk in women exposed to diethylstilbestrol in utero. Journal of the American Medical Association. 280(7), 630-634.

Hayden C, Bowler JO, Chambers S, Freeman R, Humphris G, Richards D, Cecil JE (2013): Obesity and dental caries in children: a systematic review and meta-analysis. Community Dentistry and Oral Epidemiology. 41(4), 289-308. doi: 10.1111/cdoe.12014.

Hooley M, Skouteris H, Boganin C, Satur J, Kilpatrick N (2012) Parental influence and the development of dental caries in children aged 0-6 years: a systematic review of the literature. Journal of Dentistry. 40(11), 873-885. doi:10.1016/j.jdent.2012.07.013.

Humphrey LL, Fu R, Buckley DI, Freeman M, Helfand M (2008): Periodontal Disease and Coronary Heart Disease Incidence: A Systematic Review and Meta-analysis. Journal of General Internal Medicine. 23(12), 2079-2086. doi: 10.1007/s11606-008-0787-6.

Institute of Medicine. Committee on Health and Behavior (2000): Health and behavior: The interplay of biological, behavioral, and societal influences. Washington, DC: National Academy of Sciences. http://www.nap.edu/openbook/0309070309.

Ismail AI, Ondersma S, Jedele JM, Little RJ, Lepkowski JM (2011): Evaluation of a brief tailored motivational intervention to prevent early childhood caries. Community Dentistry and Oral Epidemiology. 39(5), 433-448. doi:10.1111/j.1600-0528.2011.00613.x.

Jackson SL, Vann Jr WF, Kotch JB, Pahel BT, Lee JY (2011): Impact of poor oral health on children's school attendance and performance. American Journal of Public Health. 101, 1900-1906.

Jarman B (1990): Validation and Distribution of Scores. British Medical Journal. 289, 1578-1592.

Johnson D, Saavedra P, Sun E, Stageman A, Grovet D, Alfero C, Maynes C, Skipper B, Powell W, Kaufman A (2012): Community Health Workers and Medicaid Managed Care in New Mexico. Journal of Community Health. 37(3), 563-571. doi:10.1007/s10900-011-9484-1.

Kassebaum NJ, Bernabé E, Dahiya M, Bhandari B, Murray CJ, Marcenes W (2015): Global burden of untreated caries: a systematic review and meta-regression. Journal of Dental Research. 94, 650-658. doi:10.1177/0022034515573272.

Kay EJ, Locker D (1996): Is dental health education effective? A systematic review of current evidence. Community Dentistry and Oral Epidemiology. 24(4), 231-235.

Kearney CA (2008): School absenteeism and school refusal behavior in youth: A contemporary review. Clinical Psychology Review. 28(3), 451-471.

Kim HN, Kim JH, Kim SY, Kim JB (2017): Associations of Community Water Fluoridation with Caries Prevalence and Oral Health Inequality in Children. International Journal of Environmental Research and Public Health. 14(6), 631. doi:10.3390/ijerph14060631.

Klein HT, Palmer CE, Knutson JW (1938): Studies on dental caries I dental status and dental needs of alimentary school children. Public Health Reports. 53, 751-765.

Kolevzon A, Gross R, Reichenberg A (2007): Prenatal and perinatal risk factors for autism: a review and integration of findings. Archives of Pediatrics & Adolescent Medicine. 161(4), 326-333.

Konopka T, Paradowska-Stolarz A (2012): Periodontitis and risk of preterm birth and low birthweight-a meta-analysis. Ginekologia Polska. 83(6), 446-453.

Kumar S, Kroon J, Lalloo R (2014): A systematic review of the impact of parental socio-economic status and home environment characteristics on children's oral health-related quality of life. Health and Quality of Life Outcomes. 12, 41. doi:10.1186/1477-7525-12-41.

Kumar S, Tadakamadla J, Kroon J, Johnson NW (2016): Impact of parent-related factors on dental caries in the permanent dentition of 6-12-year-old children: A systematic review. Journal of Dentistry. 46, 1-11. doi:10.1016/j.jdent.2015.12.007.

Kwan S, Petersen PE, Pine CM, Borutta A (2005) Health promoting schools: an opportunity for oral health promotion. Bulletin of the World Health Organization. 83, 677-685.

Kwok J, Langevin SM, Argiris A, Grandis JR, Gooding WE, Taioli E (2010): The impact of health insurance status on the survival of patients with head and neck cancer. Cancer. 116(2), 476-485. doi:10.1002/cncr.24774.

Lalonde M (1974): A new perspective on the health of Canadians. Ottawa: Department of National Health and Welfare.

Lambert MJ, Vanobbergen JNO, Martens LC, De Visschere L (2017): Socio-economic inequalities in caries experience, care level and dental attendance in primary school children in Belgium: a cross-sectional survey. BMJ Open 7:e015042. doi: 10.1136/bmjopen-2016-015042.

Leake JL, Birch S (2008): Public policy and the market for dental services. Community Dentistry and Oral Epidemiology. 36(4), 287-295. doi:10.1111/j.1600-0528.2008.00438.x.

Lee JY, Divaris K (2014): The Ethical imperative of Addressing Oral Health Disparities: A Unifying Framework. Journal of Dental Research. 93(3), 224-230.

Lewis C, Teeple E, Robertson A, Williams A (2009): Preventive dental care for young, Medicaid-insured children in Washington state. Pediatrics. 124(1), 120-127. doi:10.1542/peds.2008-3089.

Listl S[a], Moeller J, Manski R (2014): A multi-country comparison of reasons for dental non-attendance. European Journal of Oral Sciences. 122(1), 62-69.

Listl S[b], Watt RG, Tsakos G (2014): Early Life Conditions, Adverse Life Events, and Chewing Ability at Middle and Later Adulthood. American Journal of Public Health. 104, 55-61.

Listl S, Galloway J, Mossey PA (2015): Global economic impact of dental diseases. Journal of Dental Research. 94(10), 1355–1361.

Lòpez R, Fernández O, Baelum B (2006): Social gradients in periodontal diseases amongst adolescents. Community Dentistry and Oral Epidemiology. 34, 184–196.

Lukacs JR (2011): Sex differences in dental caries experience: clinical evidence, complex etiology. Clinical Oral Investigations. 15(5), 649-656. doi:10.1007/s00784-010-0445-3.

Mackenbach JP (2003): An analysis of the role of health care in reducing socio-economic inequalities in health: the case of the Netherlands. International Journal of Health Services. 33, 523-541.

Mackenbach JP, Stirbu I, Roskam AR, Schaap MM, Menvielle G, Leinsalu M, Kunst AE (2008): Socio-economic inequalities in health in 22 European countries. The New English Journal of Medicine. 358(23), 2468-2481. doi:10.1056/NEJMsa0707519

Mackenbach JP, Meerding WJ, Kunst AE (2011): Economic costs of health Inequalities in the European Union. Journal of Epidemiology and Community Health. 65(5), 412-419.

Maiuro L (2011): Eliminating adult dental benefits in Medi-Cal: an analysis of impact [Internet]. Oakland (CA): California HealthCare Foundation. Available from: http://www.chcf.org/~/media/MEDIA%20LIBRARY%20Files/PDF/E/PDF%20EliminatingAdultDentalMediCalcx.pdf

Major N, McQuistan M, Qian F (2016): Changes in Dental Students' Attitudes About Treating Underserved Populations: A Longitudinal Study. Journal of Dental Education. 80(5), 517-525.

Mani A, Mullainathan S, Shafir E, Zhao J (2013): Poverty Impedes Cognitive Function. Science. 341(6149), 976-980.

Manning WG, Bailit HL, Benjamin B, Newhouse JP (1985): The demand for dental care: evidence from a randomized trial in health insurance. The Journal of the American Dental Association. 110(6), 895-902.

Manski RJ, Cooper PF (2007): Dental care use: does dental insurance truly make a difference in the US? Community Dental Health. 24(4), 205-212.

Marcenes W, Kassebaum NJ, Bernabe E, Flaxman A, Naghavi M, Lopez A, Murray CJ (2013): Global burden of oral conditions in 1990-2010: a systematic analysis. Journal of Dental Research. 92(7), 592-597.

Marmot, M. (2010): Fair society, healthy lives: The Marmot review, executive summary [Internet]. London: The Marmot Review. ISBN 978-0-9564870-0-1. Available from: http://www.instituteofhealthequity.org/projects/fair-society-healthy-lives-the-marmot-review.

Marro F, Jacquet W, Bottenberg P, Martens LC (2018): The Influence of Behavioural and Sociodemographic Risk Indicators on Erosive Tooth Wear in Flemish Adolescents, Belgium. Caries Research. 52, 119–128. doi:10.1159/000481667

Martens L, Vanobbergen J, Willems S, Aps J, De Maeseneer J (2006): Determinants of early Childhood Caries (ECC) in a group of inner city children. Quintessence International. 37(7), 527-36.

Martins MT, Sardenberg F, Bendo CB, Abreu MH, Vale MP, Paiva SM, Pordeus IA (2017): Dental caries remains as the main oral condition with the greatest impact on children's quality of life. PLOS One. 12(10), e0185365. doi:10.1371/journal.pone.0185365.

Matsuyama Y, Aida J, Taura K, Kimoto K, Ando Y, Aoyama H, Morita M, Ito K, Koyama S, Hase A, et al. (2016): School-Based Fluoride Mouth-Rinse Program Dissemination Associated With Decreasing Dental Caries Inequalities Between Japanese Prefectures: An Ecological Study. Journal of Epidemiology. 26(11), 563-571.

McLaren L, McNeil DA, Potestio M, Patterson S, Thawer S, Faris P, Shi C, Shwart L (2016): Equity in children's dental caries before and after cessation of community water fluoridation: differential impact by dental insurance status and geographic material deprivation. International Journal for Equity in Health. 15, 24. doi:10.1186/s12939-016-0312-1.

Molina MA, Cheung MC, Perez EA, Byrne MM, Franceschi D, Moffat FL, Livingstone AS, Goodwin WJ, Gutierrez JC, Koniaris LG (2008): African American and poor patients have a dramatically worse prognosis for head and neck cancer: an examination of 20,915 patients. Cancer. 113(10), 2797-806. doi:10.1002/cncr.23889.

Moynihan P (2016): Sugars and Dental Caries: Evidence for Setting a Recommended Threshold for Intake. Advances in Nutrition. 7(1), 149-56. doi:10.3945/an.115.009365.

Moysés SJ, Moysés ST, Sheiham A (2014): Promoting oral health by creating healthy environments and using the Common Risk Factor Approach. In: Promoting the Oral Health of Children Theory and Practice. 2nd Edition. Editors Aubrey Sheiham, Samuel Moysés, Richard G Watt, Marcelo Bonecker, London: Quintessence Editora Ltda. 183-218.

Mullainathan S, Shafir E (2013): Scarcity: Why Having Too Little Means So Much. Time Books, Henry Holt & Company LLC, New York.

Myria (2017) Migratie in cijfers en rechten 2017. (http://www.myria.be/files/Hoofdstuk_2.pdf)

Nasseh K, Vujicic M (2013): Health Reform In Massachusetts Increased Adult Dental Care Use, Particularly Among The Poor. Health Affairs. 32(9), 1639-1645. doi:10.1377/hlthaff.2012.1332.

Nelson S, Albert JM, Lombardi G, Wishnek S, Asaad G, Kirchner HL, Singer LT (2010): Dental Caries and Enamel Defects in Very Low birth weight adolescents. Caries Research. 44(6), 509-518. doi:10.1159/000320160.

Nomura Y, Wickramaratne PJ, Pilowsky DJ, Newcorn JH, Bruder-Costello B, Davey C, Fifer WP, Brooks-Gunn J, Weissman MM (2007): Low birth weight and risk of affective disorders and selected medical illness in offspring at high and low risk for depression. Comprehensive Psychiatry. 48(5), 470-478.

OECD[a] (2017): Income inequality (indicator). doi:10.1787/459aa7f1-en.

OECD[b] (2017): Unemployment rate (indicator). doi:10.1787/997c8750-en.

OECD[c] (2017): Employment rate (indicator). doi: 10.1787/1de68a9b-en.

Onyejaka NK, Folayan MO, Folaranmi N (2016): Barriers and facilitators of dental service utilisation by children aged 8 to 11 years in Enugu State, Nigeria. BMC Health Services Research. 16, 93. doi:10.1186/s12913-016-1341-6.

Opler MG, Susser ES (2005): Fetal environment and schizophrenia. Environmental Health Perspectives. 113(9), 1239-1242.

Oxford Centre for Evidence-based Medicine (2009): Levels of Evidence. Available from: https://www.cebm.net/2009/06/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/

Pace CC, McCullough GH (2010): The association between oral microorgansims and aspiration pneumonia in the institutionalized elderly: review and recommendations. Dysphagia. 25(4), 307-322. doi:10.1007/s00455-010-9298-9.

Palencia L, Espelt A, Cornejo-Ovalle M, Borrell C (2014): Socio-economic inequalities in the use of dental care services in Europe: what is the role of public coverage? Community Dentistry and Oral Epidemiology. 42(2), 97-105. doi:10.1111/cdoe.12056.

Perc M (2014): The Matthew effect in empirical data. Journal of the Royal Society Interface. 11(98), 20140378.

Peres MA, Peres KG, Thomson WM, Broadbent JM, Gigante DP, Horta BL (2011): The influence of family income trajectories from birth to adulthood on oral health: findings from the 1982 Pelotas birth cohort. The American Journal of Public Health. 101(4), 730-736.

Petersen PE, Bourgeois D, Ogawa H, Estupinan-Day S, Ndiaye C (2005): The global burden of oral diseases and risks to oral health. Bulletin of the World Health Organization. 83(9), 661-669.

Petersen PE, Kwan S (2011): Equity, social determinants and public health programmes—the case of oral health. Community Dentistry and Oral Epidemiology. 39(6), 481-487.

Pinket AS, De Craemer M, Maes L, De Bourdeaudhuij I, Cardon G, Androutsos O, Koletzko B, Moreno L, Socha P, Iotova V, et al. (2016): Water intake and beverage consumption of pre-schoolers from six European countries and associations with socio-economic status: The ToyBox-study. Public Health Nutrition. 19(13), 2315-2325. doi:10.1017/S1368980015003559.

Piovesan C, Ferreira Antunes JL, Mendes FM, Guedes RS, Ardenghi TM (2012): Influence of children's oral health-related quality of life on school performance and school absenteeism. Journal of Public Health Dentistry. 72(2), 156-63. doi: 10.1111/j.1752-7325.2011.00301.x.

Pitts N, Amaechi B, Niederman R, Acevedo AM, Vianna R, Ganss C, Ismail A, Honkala E (2011): Global Oral Health Inequalities: Dental Caries Task Group—Research Agenda. Advances in Dental Research. 23(2), 211-220.

Plutzer K, Keirse JNC (2011): Incidence and prevention of early childhood caries in one- and two-parent families. Child: Care, Health and Development. 37(1), 5-10. doi:10.1111/j.1365-2214.2010.01114.x.

Poulton R, Caspi A, Milne BJ, Thomson WM, Taylor A, Sears MR, Moffitt TE (2002): Association between children's experience of socio-economic disadvantage and adult health: a life-course study. The Lancet. 360(9346), 1640-1645.

Priya ND, Harikiran AG (2013): Effectiveness of oral health education programs: a systematic review. Journal of International Society of Preventive and Community Dentistry. 3(2), 103-115.

Prochaska J, Di Clemente C (1983): Stages and processes of self-change in smoking: toward an integrative model of change. Journal of Consulting and Clinical Psychology. 5, 390–395.

Quinonez C, Figueiredo R (2010): Sorry Doctor, I Can't Afford the Root Canal, I Have a Job: Canadian Dental Care Policy and the Working Poor. Canadian Journal of Public Health. 101(6), 481-485.

Radnai M, Pál A, Novák T, Urbán E, Eller J, Gorzó I (2009): Benefits of periodontal therapy when preterm birth threatens. Journal of Dental Research. 88(3), 280-284. doi:10.1177/0022034508330229.

Raittio E, Lahti S, Kiiskinen U, Helminen S, Aromaa A, Suominen AL (2015): Inequality in oral health-related quality of life before and after a major subsidization reform. European Journal of Oral Sciences. 123, 267–275.

Rapoport JL, Addington AM, Frangou S, Psych MR (2005): The neurodevelopmental model of schizophrenia: update 2005. Molecular Psychiatry. 10(5), 434-449.

Ravaghi V, Quiñonez C, Allison PJ (2013): The magnitude of oral health inequalities in Canada: findings of the Canadian health measures survey. Community Dentistry and Oral Epidemiology. 41(6):490-8.

Riggs E, Gussy M, Gibbs L, van Gemert C, Waters E, Priest N, Watt R, Renzaho AM, Kilpatrick N (2014): Assessing the cultural competence of oral health research conducted with migrant children. Community Dentistry and Oral Epidemiology. 42(1), 43-52. doi: 10.1111/cdoe.12058.

Riggs E, Rajan S, Casey S, Kilpatrick N. (2017): Refugee child oral health. Oral Diseases. 23(3), 292-299. doi:10.1111/odi.12530.

Riley JC, Lennon MA, Ellwood RP (1999): The effect of water fluoridation and social inequalities on dental caries in 5-year-old children. International Journal of Epidemiology. 28(2), 300-305. doi:10.1093/ije/28.2.300.

Rouxel Pl, Heilmann A, Aida J, Tsakos G, Watt RG (2015): Social capital: theory, evidence, and implications for oral health. Community Dentistry and Oral Epidemiology. 43(2), 97-105.

Sabbah W, Tsakos G, Chandola T, Sheiham A, Watt RG (2007): Social gradients in oral and general health. Journal of Dental Research. 86(10), 992-996

Sabbah W, Tsakos G, Sheiham A, Watt RG (2009): The role of health-related behaviors in the socio-economic disparities in oral health. Social Science & Medicine. 68(2), 298-303.

Saleh A, Yang YH, Wan Abd Ghani WM, Abdullah N, Doss JG, Navonil R, Abdul Rahman ZA, Ismail SM, Talib NA, Zain RB, et al. (2012): Promoting oral cancer awareness and early detection using a mass media approach. Asian Pacific Journal of Cancer Prevention. 13(4), 1217-1224.

Sanders AE, Slade GD, Turrell G, Spencer AJ, Marcenes W (2006): The shape of the socio-economic-oral health gradient: implications for theoretical explanations. Community Dentistry and Oral Epidemiology. 34, 310-319.

Schou L, Wight C (1994): Does dental health education affect inequalities in dental health? Community Dental Health. 11(2), 97-100.

Schuch HS, Peres KG, Singh A, Peres MA, Do LG (2017): Socio-economic position during life and periodontitis in adulthood: a systematic review. Community Dentistry and Oral Epidemiology. 45(3), 201-208. doi:10.1111/cdoe.12278.

Schweinhart LJ (2005): Lifetime Effects: The High Scope Perry Preschool Study Through Age 40. Ypsilanti, MI: High/Scope Press. 239.

Schwendicke F, Dörfer CE, Schlattmann P, Page LF, Thomson WM, Paris S (2015): Socio-economic inequality and caries: a systematic review and meta-analysis. Journal of Dental Research. 94(1), 10-18.

Seirawan H, Faust S, Mulligan R (2012): Impact of oral health on the academic performance of disadvantaged children. American Journal of Public Health. 102(9), 1729-1734. doi:10.2105/AJPH.2011.300478.

Sgolastra F, Severino M, Pietropaoli D, Gatto R, Monaco A (2013): Effectiveness of periodontal treatment to improve metabolic control in patients with chronic periodontitis and type 2 diabetes: a meta-analysis of randomized clinical trials. Journal of Periodontology. 84(7), 958-973. doi:10.1902/jop.2012.120377.

Sheiham A, Watt RG (2000): The common risk factor approach: a rational basis for promoting oral health. Community Dentistry and Oral Epidemiology. 28, 399-406.

Sheiham A, Nicolau B (2005): Evaluation of social and psychological factors in periodontal disease. Periodontology 2000. 39, 118-131.

Shonkoff JP, Phillips D (2000): National Research Council (US) and Institute of Medicine (US) Committee on Integrating the Science of Early Childhood Development. From Neurons to Neighborhoods: The Science of Early Childhood Development. Washington, DC: National Academy Press; 2000, 588.

Shonkoff JP, Boyce WT, McEwen BS (2009): Neuroscience, Molecular Biology, and the Childhood Roots of Health Disparities. Building a New Framework for Health Promotion and Disease Prevention. Journal of the American Medical Association. 301(21), 2252–2259. doi:10.1001/jama.2009.754

Silness J, Löe H (1964): Correlation between oral hygiene and periodontal condition. Acta Odontologica Scandinavica. 22, 121-135.

Simpson TC, Weldon JC, Worthington HV, Needleman I, Wild SH, Moles DR, Stevenson B, Furness S, Iheozor-Ejiofor Z (2015): Treatment of periodontal disease for glycaemic control in people with diabetes. The Cochrane Database of Systematic Reviews. 11, CD004714. doi:10.1002/14651858.CD004714.pub3.

Singh A, Rouxel P, Watt RG, Tsakos G (2013): Social inequalities in clustering of oral health-related behaviors in a national sample of British adults. Preventive Medicine. 57(2), 102-106.

Singhal A, Caplan DJ, Jones MP, Momany ET, Kuthy RA, Buresh CT, Isman R, Damiano PC (2015): Eliminating Medicaid Adult Dental Coverage in California led to increased dental emergency visits and associated costs. Health Affairs (Millwood). 34(5), 749-756. doi:10.1377/hlthaff.2014.1358.

Singhal S, Correa R, Quiñonez C (2013): The impact of dental treatment on employment outcomes: a systematic review. Health Policy. 109(1), 88-96. doi: 10.1016/j.healthpol.2012.09.016.

Sprod A, Anderson R, Treasure E (1996): Effective oral health promotion. Literature review. Cardiff: Health Promotion Wales.

Sogaard AJ, Tuominen R, Holst D, Gjermo P (1987): The effect of 2 teaching programs on the gingival health of 15-year-old schoolchildren. Journal of Clinical Periodontology. 14, 165-70.

Solar O, Irwin A (2010): A conceptual framework for action on the social determinants of health. Social determinants of health discussion paper 2 (Policy and Practice). Geneva: World Health Organization.

Stad Gent. Cijfers en trends, Kansarmoedeatlas, 2011 [Internet]. Available from: http://www4.gent.be/gent/wonen/kansarmo/atlas99/index.htm.

Statistics Belgium. (2012): The statistical sector: a little-known subdivision of the municipality. [Internet]. Available from: http://statbel.fgov.be/en/statistics/organisation/statistics_belgium/dissemination/statbel/in_the_spotlight_archives/in_the_spotlight_2012/the_statistical_sector.jsp.

Stewart B, Wild C. (2014): World cancer report 2014. Lyon, France: International Agency for Research on Cancer. World Health Organization.

Stichting tegen Kanker – Rookgedrag in België 2017. [Internet] Available from: https://www.kanker.be/sites/default/files/stichting_tegen_kanker_-_enquete_rookgedrag_2017_1.pdf.

Streiner L, Norman R (2003): Health Measurment Scales. A practical Guide to Their Development and Use. Oxford University Press, New York.

Syme SL (2004): Social determinants of health: the community as an empowered partner. Preventing Chronic Disease. 1(1), A02.

Telford C, Murray L, Donaldson M, O'Neill C (2012): An analysis examining socio-economic variations in the provision of NHS general dental practitioner care under a fee for service contract among adolescents: Northern Ireland Longitudinal Study. Community Dentistry and Oral Epidemiology. 40(1), 70-79. doi: 10.1111/j.1600-0528.2011.00649.x.

Thomson WM, Poulton R, Milne BJ, Caspi A, Broughton JR, Ayers KMS (2004): Socio-economic inequalities in oral health in childhood and adulthood in a birth cohort. Community Dentistry and Oral Epidemiology. 32(5), 345-353.

Townsend P, Davidson N (1982): Inequalities in Health: the Black Report. Harmondsworth: Penguin Books.

Townsend P, Phillimore P, Beattie A. (1988): Health and Deprivation: Inequality and the North. Routledge, London.

Triandafyllidou A (2009): Clandestino project - Final Report. [Internet]: Available from: http://cordis.europa.eu/documents/documentlibrary/126625701EN6.pdf.

Tsakos G, Demakakos P, Breeze E, Watt RG (2011): Social gradients in oral health in older adults: findings from the English longitudinal survey of aging. American Journal of Public Health. 101(10):1892-9.

Twetman S (2008): Prevention of early childhood caries (ECC): review of literature published 1998-2007. European Archives of Paediatric Dentistry. 9(1), 12-18.

Ulhaq A, McMahon AD, Buchanan S, Goold S, Conway DI (2012): Socio-economic deprivation and NHS orthodontic treatment delivery in Scotland. British Dental Journal. 213(4), 5. doi:10.1038/sj.bdj.2012.724.

Van den Branden S, Van den Broucke S, Leroy R, Declerck D, Hoppenbrouwers K (2013): Oral health and oral health-related behaviour in preschool children: evidence for a social gradient. European Journal of Pediatrics. 172, 231-237. doi:10.1007/s00431-012-1874-6.

Van der Velden U (2009): The Dutch periodontal screening index validation and its application in The Netherlands. Journal of Clinical Periodontology. 36(12), 1018-1024.

Van Oyen H, Charafeddine R, Deboosere P, Cox B, Lorant V, Nusselder W, Demarest S (2011): Contribution of mortality and disability to the secular trend in health inequality at the turn of century in Belgium. European Journal of Public Health. 21(6), 781-787

Vanobbergen JN, Martens LC, Lesaffre E, Declerck D (2001): Parental occupational status related to dental caries experience in 7-year-old children in Flanders (Belgium). Community Dental Health. 18(4), 256-262.

Vanobbergen J, De Visschere L, Daems M, Ceuppens A, Van Emelen J (2010): Socio-demographic determinants for oral health risk profiles. International Journal of Dentistry. 2010, 938936. doi:10.1155/2010/938936.

Watt RG, Marinho VC (2005): Does oral health promotion improve oral hygiene and gingival health? Periodontology. 37(1), 35-47.

Watt RG (2007): From victim blaming to upstream action: tackling the social determinants of oral health inequalities. Community Dentistry and Oral Epidemiology. 35(1), 1-11.

Watt RG, Sheiham A (2012): Integrating the common risk factor approach into a social determinants framework. Community Dentistry and Oral Epidemiology. 40(4), 289-296.

Watt RG, Listl S, Peres M, Heilmann A (2015): Social inequalities in oral health: from evidence to action. UCL, London (UK). ISBN:978-0-9527377-6-6.

Willems S, Vanobbergen J, Martens L, De Maeseneer J. (2005) The independent impact of Household- and neighbourhood-based social determinants on Early Childhood Caries. Family & Community Health. 28, 168-175.

WHO (2005): Preventing chronic diseases: a vital investment. 2005. Geneva: World Health Organization.

WHO (2008): Commission on Social Determinants of Health. Closing the gap in a generation. Health equity through action on the social determinants of health. Geneva: World Health Organization.

WHO (2009): Background Note: Regional Preparatory Meeting on Promoting Health Literacy [Internet]. UN ECOSOC.

CURRICULUM VITAE

Personal Data

Name:	Lambert
first name:	Martijn
Place of birth	Deinze
Date of birth	19/06/1991
Sex	Male
Nationality	Belgium
Civil status	Unmarried
Home address	Keltenlaan 37, 9880 Aalter
Current place of residence	Keltenlaan 37, 9880 Aalter
Home telephone	+329 375 07 09
Work telephone	+32494 89 64 42
E-mail	Martijn.Lambert@Ugent.be

Study Curriculum:

Degree	Deliberation Date	Results	Institution
Secondary School Latin-Maths	30/06/2009	Magna Cum Laude 840/1000	Emmaüsinstituut Aalter
1st Bachelor of science in Dentistry	05/07/2010	725/1000	Ghent University
2nd Bachelor of science in Dentistry	07/07/2011	779/1000	Ghent University
Diploma Bachelor of science in Dentistry	05/07/2012	Magna Cum Laude 765/1000	Ghent University
1st Master of science in Dentistry	04/07/2013	730/1000	Ghent University
Diploma Master of science in Dentistry	24/06/2014	Magna Cum Laude 764/1000	Ghent University
Postgraduate Professional Title General Dentist	23/06/2015	Succeeded no marks assigned	Ghent University
Doctoral School	Currently		Ghent University

Student rewards:

Amonis Community Dentistry Award (Ghent University; 24/06/2014)

Dr Priem Excellence Award (Ghent University; 24/06/2014)

Professional Career

General Dentist:		
Hofakkerlaan 13, 8750 Wingene (Belgium)	2/5 FTE	01/07/2014 - present
Hundelgemsesteenweg 145, 9000 Ghent (Belgium)	1/5 FTE	01/07/2014 – present
Researcher/PhD Student:		
Dental School, Community Dentistry and Oral Public Health **Corneel Heymanslaan 10 P8, 9000 Ghent (Belgium)**	2/5 FTE	01/10/2015 – present

Professional Membership

-International Association for Dental Research (IADR)

-European Association of Dental Public Health (EADPH)

-Ghent Oral Health Council (Belgium)

-Consortium Preventive Oral Health Care (Flemish government, Belgium)

-Alliance of Flemish Dentists (VVT) (Belgium)

-Professional Organisation of Flemish Dentists (VBT) (Belgium)

Scientific Outcome

- Publications:

A1-publications:

Socio-economic inequalities in caries experience, care level and dental attendance in primary school children in Belgium: a cross-sectional survey
Lambert Martijn J, Vanobbergen Jacques, Martens Luc C, De Visschere Luc MJ.
BMJ Open. 2017. BMJ. 7 (7). doi: 10.1136/bmjopen-2016-015042

Social gradient in caries experience of Belgian adults 2010.
Lambert MJ, De Reu G, De Visschere LMJ, Declerck D, Bottenberg P, Vanobbergen JNO.
Community Dental Health. 2018. 2018 (35) p.1-7
[accepted for publication on 2017-12-29]

Effect of an oral healthcare programme on care staff knowledge and attitude regarding oral health: a non-randomised intervention trial.
Janssens B, Vanobbergen J, Lambert M, Schols MGA, De Visschere L. Clin Oral Invest (2018) 22:281–292. Doi: 10.1007/s00784-017-2110-6

Accessibility to oral health care for people on social assistance: a survey of social service providers from Public Welfare Centers in Flanders
Verheire F, De Visschere L, Fernandez C, Lambert M, Marks L.
International Dental Journal
[accepted for publication on 2018-01-20]

The impact of a nationwide oral health promotion program on oral health and oral health inequalities: A prospective 4-year longitudinal intervention study in primary school children in Flanders-Belgium.
Lambert MJ, De Visschere LMJ, Martens LC, Deschepper E, Vanobbergen JNO.
Community Dental Health
[submitted]

Including community oral health workers in an oral health care path targeting socially vulnerable high-risk groups: protocol of a prospective, two-year longitudinal cluster randomised controlled trial.
Lambert MJ, Vanobbergen JNO, De Visschere LMJ.
BMC Oral Health
[submitted]

- Poster presentations:

European Association of dental Public Health 2015 Congress (17 to 19 September 2015, Istanbul, Turkey)
The knowledge and attitude of dental students towards child abuse and neglect
LAMBERT MJ; MARTENS LC; VANOBBERGEN J; DE VISSCHERE L.

European Association of Dental Public Health 2016 Congress (30 September to 1 October 2016, Budapest, Hungary)
Socio-economic inequalities in oral health aspects in primary school children
LAMBERT M, VANOBBERGEN J, MARTENS LC, DE VISSCHERE L.

European Association of Dental Public Health 2017 Congress (8 June to 10 June 2017, Vilnius, Lithuania)
Oral health status of undocumented immigrants in Ghent, Belgium
LAMBERT MJ, VANOBBERGEN J, DE VISSCHERE L.

-Governmental Projects

August 2016- December 2016: Ministry of Welfare, Public Health and Family (Jo Vandeurzen): Development of a validated educational program for Community Oral Health Workers. (MB_2016_20160718):

September 2017- December 2018: Ministry of Welfare, Public Health and Family (Jo Vandeurzen): Training of Community Oral Health Workers in Flanders. (17-22147 MB sub PO MGZ mondcoach 2017)