Lien Nguyen

Dental Service Utilization, Dental Health Production and Equity in Dental Care: the Finnish Experience

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Dental Service Utilization, Dental Health Production and Equity in Dental Care: the Finnish Experience

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Helsinki, February 8, 2008

Lien Nguyen
Abstract


This thesis is grounded on four articles. Article I examines the factors affecting dental service utilization and the role of supply factors in the utilization process. Article II studies the factors associated with sector-specific utilization among those entitled to age-based subsidized dental care. Article III explores the determinants of dental ill-health as measured by the occurrence of caries and the relationship between dental ill-health and dental care use. Article IV measures and explains income-related inequality in utilization. Data employed were from the 1996 Finnish Health Care Survey (I, II, IV) and the 1997 follow-up study included in the longitudinal study of the Northern Finland 1966 Birth Cohort with additional information relating to the past (III). The context for the estimation of utilization models is the regulated and segmented Finnish dental care market. Utilization is theoretically considered as a multi-stage decision-making process and empirically measured as the number of visits to the dentist. Modified count data models and concentration and horizontal equity indices were applied.

Dentists' recall appeared very efficient at stimulating individuals to seek care. Dental pain, recall, and the low number of missing teeth positively affected utilization. Public subvention for dental care did not seem to affect utilization. Among young adults, a perception of insufficient public availability and recall were positively associated with the choice of a private dentist, whereas income and dentist density were positively associated with the number of visits to private dentists. Among cohort females, factors increasing caries were body mass index and intake of alcohol, sugar, and soft drinks and those reducing caries were birth weight and adolescent school achievement. Among cohort males, caries was positively related to the metropolitan residence and negatively related to healthy diet and education. Smoking increased caries, whereas regular teeth brushing, regular dental attendance and dental care use decreased caries. We found equity in young adults' utilization but pro-rich inequity in the total number of visits to all dentists and in the probability of visiting a dentist for the whole sample. For the latter, two main factors related to the pro-rich distributions of use were income and recall. We observed inequity in the total number of visits to the dentist and in the probability of visiting a dentist, being pro-poor for public care but pro-rich for private care.

The findings suggest that to enhance equal access to and use of dental care across population and income groups, attention should focus on supply factors and incentives to encourage people to contact dentists more often. Lowering co-
payments and service fees and improving public availability would likely increase service use in both sectors. To attain favorable oral health, appropriate policies aimed at improving dental health education and reducing the detrimental effects of common risk factors on dental health should be strengthened. Providing equal access with respect to need for all people ought to take account of the segmentation of the service system, with its two parallel delivery systems and different supplier incentives to patients and dentists.

Keywords: Demand, utilization, dental care, choice of sector, dental health, health production function, equality, equity, count data, Finland
Abstract in Finnish


Avainsanat: kysyntä, käyttö, hammashuolto, sektorivalinta, suunterveys, terveyden tuotantofunktio, eriarvoisuus, oikeudenmukaisuus, count data, Suomi

Dental Service Utilization, Dental Health Production and Equity in Dental Care: the Finnish Experience

Research Report 173
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Abstract in Swedish


Resultaten pekar på att jämlikheten mellan olika befolkningsgrupper och inkomstklasser när det gäller utnyttjandet av tandvården inte främjas om man inte på utbudssidan samtidigt ger akt på de faktorer och incitament som motiverar människorna att oftare söka sig till tandvården. En sänkning av service- och kundavgifterna och en förbättring av tillgången på offentliga tandvårdstjänster skulle sannolikt öka utnyttjandet av tjänsterna inom vardera sektorn. För att uppnå en gynnsam munhälsa behövs stöd av åtgärder som ökar hälsofostran beträffande munhälsa och minskar skadeverkningarna från allmänna riskfaktorer. För att ge hela befolkningen möjlighet till en behövlig, jämlik vård borde man uppmärksamma servicesystemets segmentering, eftersom det innehåller två parallella vårdsktor och olika leverantörsincitament för patienter och tandläkare.

Nyckelord: efterfrågan, utnyttjande, tandvård, sektorsval, munhälsa, hälsoproduktion, ojämlikhet, rättvisa, count data, Finland
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Introduction
1 Background

Dental health is ultimately the main objective and product of dental care. With the development of the theory of human capital, the economic approach to the demand for dental health and dental care has considered the demand for dental care as being derived from the demand for dental health (Grossman 1972a; Grossman 2000; Grossman 1972b). Both individuals and service providers can substantially influence demand for and utilization of dental care (Parkin and Yule 1988). Since the primary goal of dentistry is to produce good dental health, improvement in dental health is an important indicator of the overall performance of the dental care system. Changes in dental health have an impact on the demand for and utilization of dental services. In turn, utilization also has an influence back on dental health.

Equity in access to health care has been explicitly endorsed as one of the central objectives in the policy documents of many states of the Organization for Economic Cooperation and Development (Hurst and Jee-Hughes 2001; van Doorslaer et al. 1993). Likewise in Finland, equal access to health care has been traditionally pursued through health policy for the last three decades (Ministry of Social Affairs and Health 1989). A yardstick often used in international comparisons is the principle of horizontal equity. According to this principle, people in equal need of health care ought to be treated equally, irrespective of characteristics such as income, place of residence and social background.

Finland has a mixed dental care system with two parallel delivery systems: the public (municipal) sector and the private sector. Constrained resources have imposed limitations upon the public sector’s supply of dental services. Although public subsidies cover services provided by both sectors, these have different remuneration systems with differences in cost sharing by patients. Both delivery systems have indeed offered more choice for those demanding dental care. However, they have also created barriers and provider-offered incentives related to dental care use, such as an uneven distribution across regions in the country of the sector-specific supply of dental care (Arinen et al. 1998; Widström et al. 1997) and the inducement posed by recalls typically practiced by private dentists in Finland (Sintonen 1986; Sintonen and Maljanen 1995). In addition, until 2000 both access to public dental care and entitlement to National Health Insurance reimbursement of private dental costs only covered, as per statute, young adults. The presence of different payment systems along with the public sector’s restricted resources and the limited access to publicly subsidized dental care has generated a self-selection mechanism that has led to segmentation of the service system. The public sector has served children, adolescents, young adults and those worse off, whereas the private sector has served the middle-aged, elderly and those better off. These factors may have had implications for socioeconomic equity in dental care utilization.
A large body of research has identified the factors affecting dental care utilization and especially the importance of income and dental insurance in the demand for and utilization of dental services (see e.g. Álvarez and Delgado 2002; Grönqvist 2004; Olsson 1999; Sintonen and Linnosmaa 2000; Stoyanova 2004; Suominen-Taipale 2000). Since the studies of the early 1990s (Arinen 1992; Arinen and Sintonen 1994; Sintonen and Maljanen 1995), there has been no further research that explores the factors affecting dental care utilization and the choice of service sectors as a decision-making process of utilization in Finland. The dental care markets have changed toward segmentation with the sectors having been opted for by different clienteles. The age eligible for publicly subsidized dental care has been extended through changes in health policy. This has not only affected both public and private provision but has also underlined more the role of the private sector in the provision of dental care in Finland (Mikkola et al. 2007). The young have had a lower need for care owing to general improvements in oral health, whereas the middle-aged and the elderly have still been in high need of care relating to specialized dental care and prosthetic devices (Suominen-Taipale et al. 2004). As the process has taken time, the implied changes would call for research that provides a relatively newer picture of and information on utilization and sector choices in dental care. Likewise, other than the Rand Health Insurance Study (Bailit et al. 1985) that examined the relationship between dental insurance and oral health, no studies have investigated whether dental care use has an impact on the oral health status of individuals. Some international studies have used European Community Household Panel data from 1996 and 2000 to explore income-related inequality in the use of dental services in several European countries, including Finland (Koolman and van Doorslaer 2004; van Doorslaer and Masseria 2004). However, no study has looked into income-related inequality in the use of dental services using Finnish data or has examined that inequality by service sector.

This thesis investigates the factors affecting dental service utilization and income-related inequality in the use of dental services in Finland. It estimates several models of the use of dental services that treat the decision-making process of utilization as a multi-stage process. It examines the factors affecting oral health, allowing not only dental care utilization but also those variables influencing utilization to have impacts on oral health. The empirical analyses are based on samples draw from the 1996 Finnish Health Care Survey and the 1997 follow-up study, the latter of which was included in the longitudinal study of the Northern Finland 1966 Birth Cohort study. This thesis gives more insight into the relationship between oral health and dental care utilization as well as the association between oral health and education over the life cycle. In addition to an understanding of the use of dental services in a dual-channel financed health care system, the thesis also contributes to understanding how income-related inequality in the use of dental services are related to the specific characteristics of the Finnish dental care system.
2  THE FINNISH INSTITUTIONAL CONTEXT

2.1 The dental care system

Local authorities (municipalities) are responsible for arranging health care services for their residents. In general, legislation does not regulate in much detail the range of services and the means of organizing them. This is often left to the discretion of the municipalities, who organize and arrange the services according to their own resources and their population’s need. Primary health care is mainly provided in public health centers operated by municipalities or federations of municipalities. The private health care system supplements the municipal system. Oral health services are provided by both private and public dental sectors. The latter also includes a small and separate segment encompassing student oral health care and army dental clinics.

Municipal health services are financed by state grants, municipal income taxes, and user charges. Private health services are partly reimbursed by the National Health Insurance (hereafter NHI). The state participates in the financing of services by paying a general, non-earmarked lump-sum grant to the municipalities according to certain need criteria. State revenues are collected from progressive direct income taxes and indirect taxes. Municipal income tax is a flat rate, which varies across municipalities. The NHI is financed by contributions from employers, the insured, and the state (Järvelin 2002). The state, municipalities, NHI, and households contributed 24%, 38%, 14%, and 20% respectively to the financing of the total health care expenditure in 1996. Private health insurance roughly accounted for 2% of that overall financing.

In 1996, children and adolescents up to their 19th birthday received public dental care free of charge. The municipalities were obliged by law to provide dental care to those born in 1956 or later. These adults were entitled to municipal dental care at subsidized fees, but they could also use private dentist services and then claim a reimbursement from the NHI. Due to differences in size and resources of the municipal health centers, their capacity to provide dental services also varied. While access to municipal dental care was rather universal in rural areas and small towns, it was restricted in urban areas and big cities. About 20% of the population lived in municipalities where health centers provided dental services for the whole

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1 During 1993–1996, the grant payable to a municipality for the running costs of municipal health services depended on its financial capacity, age structure, mortality, population density, and land area (Häkkinen and Järvelin 2004). Since 1997, the criteria for the grant have been the age structure and the number of disability pensions. In addition to health care, municipalities’ revenues and state grants are also allocated to other services such as education and social services.
population in 1996; most of those municipalities were quite small, with a few or no private practitioners (Widström et al. 1997). As such, entitlement to subsidized dental care and to NHI reimbursements for basic treatments given by private dentists was confined to the population groups above-mentioned but adults’ access to public dental care also varied considerably between municipalities. As a result, a significant proportion of the adult population was excluded from public care, and they had to pay all the costs of private dental services.

The user fees of public dental services have been determined by regulation. The public health centers charge dental services at fixed user fees. The central government gives recommendations on maximum user fees for dental services, but each municipality determines its own user fees. The NHI reimburses 60% of private dentist’s fees according to its own fixed tariff schedule endorsed by the Ministry of Social Affairs and Health. Prices for private dental services have not been regulated since the beginning of 1993 (Arinen et al. 1998). Therefore, in practice fees charged by private dentists for their services are actually higher than the NHI basic tariffs set for the same services. There is no private dental insurance. In 1996, the dentist to population ratio was 1:1098 and overall, half of the dentists practiced in the public service sector (Valgaama 2003). User charges contributed 62% to the total oral health care financing, while the municipalities (including state grants) contributed 30% and the NHI 8% (Social Insurance Institution 2000). The main features of the Finnish dental care system in 1996 are summarized in Table 1.

**TABLE 1. Main features of the Finnish dental care system in 1996**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Public dental system</th>
<th>Private dental system</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 0–18 years</td>
<td>Free of charge, priority care</td>
<td>60% NHI subsidy* (0% for orthodontics and prosthetics), in effect 35–40% reimbursement</td>
</tr>
<tr>
<td>Age 19–40 years</td>
<td>Eligible for subsidized dental care</td>
<td></td>
</tr>
<tr>
<td>Age 41+ years</td>
<td>Subsidized dental care in some small municipalities</td>
<td>All dental fees paid by users</td>
</tr>
<tr>
<td>World War II veterans</td>
<td>Subsidized dental care</td>
<td>60–100% NHI subsidy*</td>
</tr>
<tr>
<td>People with certain diseases</td>
<td>Subsidized dental care</td>
<td>60% NHI subsidy* for some selected treatments</td>
</tr>
<tr>
<td><strong>Attribute of dental care</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>Cheaper than private dental care, low user fees</td>
<td>Always more expensive than public dental care, high co-payments</td>
</tr>
<tr>
<td>Availability</td>
<td>Restricted capacity, yet good in some rural areas</td>
<td>Good in urban areas and highly populated centers</td>
</tr>
<tr>
<td>Dentist’s payment system</td>
<td>Monthly salaryb</td>
<td>Fixed fee-for-service basis</td>
</tr>
<tr>
<td>Dentist’s recall</td>
<td>To those under 18 years</td>
<td>To adult clients</td>
</tr>
<tr>
<td>Share of visits to dentistsc</td>
<td>ca. 40%</td>
<td>ca. 60%</td>
</tr>
</tbody>
</table>

* Based on the National Health Insurance (NHI) own fixed tariffs for treatments and procedures provided by private dentists. Some private dental services are not compensated at all.
* 20–30% of their remuneration is comprised of fees for services.
* Visits to dentists were made by those aged at least 18 years (Manderbacka et al. 2006).
2.2 Oral health and the development of dental care provision

The development of the supply of dental services in Finland since the 1950s until 2000 can be considered to rest on several main cornerstones. All along, top priority has always been given to children and adolescents. The School Dental Care Act (1957) stated that publicly financed school dental care should be systematically arranged for first-graders for a ten year period (Jyväskylä City 1995). In 1972, the implementation of the Primary Health Care Act enabled children aged 0–16 years to receive municipal dental care free of charge. In 1986, a direct subsidy scheme for dental care was introduced to young adults born in 1961 or later (age 17–25 years). These were eligible for municipal dental care at subsidized fees and for the NHI reimbursements for private dentist services. In 1990, the statutory age concerning the use of subsidized dental care in both sectors extended eligibility to people born in 1956 or later (age 18–34 years) (for more details, see Nordblad et al. 2004). The public subsidy scheme for these young people was—via a reduction in dental costs—meant to improve access to dental care in both sectors measured as a higher likelihood of having a dental visit and to increase the amount of dental care consumed.

For children aged under 17, high priority has been set for oral health education and preventive dental care by means of check-ups. In the 1980s, they were annually recalled for a check-up visit to health center dentists. Since the 1990s, a need-based individual care interval has been applied. Currently, every child has an individual recall interval for preventive dental care depending on own oral health status. However, recall is expected to take place at least once every two years (Nordblad et al. 2004).

Fluoride treatment was tested and given to pupils in the 1960s (Jyväskylä City 1995), and since then the use of fluoride-containing toothpaste has become common. Between 1976 and 1996, the proportion of the 12-year old children without dental caries increased from 1% to 35%, whereas the DMFT-index (describing the mean number of decayed, missing or filled teeth) decreased from 6.7 to 1.2 and regional differences in their oral health have diminished (Nordblad et al. 2004). The percentage of edentulous people among those aged at least 15 years decreased from 22% (Nyman 1980) to 14% (Arinen et al. 1998). The dentist to population ratio almost doubled between 1965 and 1996 (Valgaama 2003). During the period 1987–1996, the share of total health care expenditure spent on oral health care shrank from 6% to 5.5%, while the out-of-pocket payments contributed by households to the oral health care financing rose from 59% to 62% (Social Insurance Institution 2000). At the same time, the share of visits to health center dentists made by those aged at least 18 years increased from 30% to 38%,

2 The fact was that the consumer prices for health care rose at a higher rate than general consumer prices (Arinen et al. 1998).
whereas the share of visits to private-sector dentists of this age group decreased from 66% to 57% (Manderbacka et al. 2006). However, among individuals that had at least one visit to the dentist, the proportion of those being recalled by the dentist increased from 28% to 39%.

3 The figures were my own calculations using the Finnish Health Care Surveys of 1987 and 1996 (Arinen et al. 1998).
3 Basic approaches to studying demand for and equity in dental care

One review in dental economics exists that deals with the demand for and utilization of dental care (Sintonen and Linnosmaa 2000), while another looks at issues relating to equity in health care financing and delivery (Wagstaff and Van Doorslaer 2000). Since these fundamental issues are thoroughly discussed in the reviews, here we only briefly present the essential literature and the main economic approaches considered in our study.

3.1 Demand for and utilization of dental care

In the earlier literature on the demand for dental care, no distinction was made between a dental care service and a typical market good. Being treated like any other market commodity, the consumption of dental care was defined within the framework of traditional neoclassical consumer theory (Andersen and Benham 1970; Feldstein 1973). In a model outlined by Becker (1965) in his theory of the allocation of time, households are assumed not only to consume goods and services but also to produce them. By using their own time and market goods, households produce basic commodities from which they derive utility. The utility related to a market good is thus dependent upon the time allocated to the consumption of that good. Hence, in addition to the traditional income budget constraint, utility maximization should also take into account both time resources and appropriate production technologies.

Using Becker’s household production approach to build up a model of the demand for health, as regards dental health here, Grossman comprehended that consumers do not demand dental care (as applied here) per se, but rather dental health for their well-being (Grossman 1972a; Grossman 1972b; Grossman 2000). The demand for dental care is derived from the demand for dental health. The consumers combine their time and market commodities as inputs to produce their own dental health. Dental health is considered to have the same properties as durable capital stock that directly enters the utility function together with other market goods consumed by individuals. An individual’s initial stock of oral health depreciates over time, but it can be increased by investments in dental care. Dental care services are sought because of their potential for preventing the depletion of good oral health and improving oral health. The individual’s stocks of other
human capital, particularly stock of knowledge or education are assumed to affect the efficiency of the oral health production process. On the constraint side, income basically determines the set of feasible choices between dental care and other goods. Grossman’s demand theory has traditionally been applied on the demand side in the analysis of dental care utilization.

Among theories applied to the supply side that can influence the demand for and utilization of dental care, supply inducement and rationing are generally drawn upon (Cooper 1975; Evans 1974). As argued by Arrow (1963), health care is different from other goods and services in important respects. Due to the incomplete and asymmetric information generally prevailing in dental care markets, patients are usually not aware of the kinds of treatment, the quality of care and the optimal amount of care services needed when they demand dental care. By acting as imperfect agents, dentists can influence patients’ consumption of their services. At a given fixed price, they reduce demand by shifting the demand curve to the left (rationing) or induce demand by shifting the demand curve to the right (SID, supplier-induced demand). SID is defined to be anything that a patient who has perfect information and knowledge would not demand but that the physician orders for him/her (Ryan and Mooney 1992). Owing to the lack of theoretical models and problems in empirical analyses of SID, no consensus within the literature of health economics has been reached for the SID hypothesis (see Labelle et al. 1994; Sintonen and Linosmaa 2000). However, efforts to test the existence of SID in dentistry have traditionally relied on the positive correlation between individual utilization of dental care and the dentist to population ratio (Grytten et al. 1993; Grytten et al. 1990; Manning and Phelps 1979; Mueller and Monheit 1988; Olsson 1999). Another hypothesis on SID—physicians’ target income—states that physicians create more demand to maintain their income levels as a response to an increase in the supply of physicians in unregulated markets (Evans 1974).

Studying the existence of SID in a fee-regulated dental market where dentist fee-for-services are used, Birch (1988) assumed that a rise in the number of dentists leads to a fall in time price and thus in the total shadow price of a dentist service. This in turn brings about an increase in the demand for dental care. As there is an increase in both the number of visits to dentists per capita and the average content of treatment per visit, a positive correlation between those two variables is sufficient but not necessary evidence for the existence of SID in the fee-regulated dental market environment (Birch 1988). Measuring supplier inducement, Sintonen and Maljanen (1995) distinguished individual inducement and general inducement. The former, being defined as the probability of being recalled by the dentist, aims to directly affect certain patient-consumers in Finland. The latter occurs through strong, continual, and systematic efforts made by Finnish dental authorities and associations and individual suppliers that aim to persuade people to adopt a regular pattern of visiting a dentist. These forms of inducement were also examined in another Finnish empirical study (Arinen et al. 1991).
The use of dental services depends on the out-of-pocket price faced by the patient. Other factors unique to dentistry that have impacts upon demand for dental services are third party payment schemes and public subsidy schemes. Third-party payers of dental services make use of the traditional insurance cost-sharing mechanisms of deductible and coinsurance. Consumers are responsible for the payment of a deductible (a fixed amount of money) and/or coinsurance (an amount based on a percentage of costs). Cost sharing is expected to exert an influence on the quantity of the health care services consumed (Chalkley and Robinson 1997). A cost-sharing mechanism in dentistry also somewhat controls patient demand for dental services and/or consumer moral hazard. Coverage levels of dental insurance are assumed to affect the amount and the mix of care services consumed. The Rand Health Insurance Study in the USA, where the organization of dental service production and insurance are mostly private, showed that there was a negative correlation between the consumption of dental services and the percentage of the costs patients paid for their dental services (Manning et al. 1985). In addition, those in the no-user-charge plan had better periodontal health and fewer decayed teeth than did those in the cost-sharing plans (Bailit et al. 1985). Owing to the presence of insurance, the structure of demand was also found to change toward more expensive dental services (Mueller and Monheit 1988) (for a review of the impact of dental insurance on the demand for dental services in the USA, see Bendall 1995).

With the aim of improving adults’ access to dental care, public subvention has been used to lower cost barriers in the Nordic countries. In Sweden, public dental insurance, launched in 1974 and ended in 1998, was found to simultaneously improve oral health and boost the market of expensive dental services (Widström and Barenthin 1997). In Denmark, a new, observed utilization pattern was associated with the provision of dental services to adults insured under the Danish Health Insurance system during the period 1975–1990 (Schwarz 1996). That new utilization pattern, consisting predominantly of diagnostic/preventive dental services, replaced the previous pattern, which contained predominantly restoration/extraction treatments. In Finland, the introduction of a direct price-subsidy scheme for dental care in 1986 resulted in a higher tendency among young adults to seek care (Arinen et al. 1991). However, in Norway no effect of subsidized dental care on young men’s utilization was found (Grytten et al. 1996).

4 As a matter of fact, the result could be considered as to reflect the overall improvement in oral health among Danish adults (Schwarz 1996).
3.2 Equity in the delivery of health care

In terms of health care utilization, two dimensions of equity are identified (Culyer and Wagstaff 1993). Vertical equity requires the appropriately unequal treatment of individuals having different degrees of treatment need. Horizontal equity is concerned with the equal treatment for individuals in equal need of treatment. There are three main principles of equity commonly discussed: equal access to health care for those in equal need of health care, equal utilization of health care for those in equal need of health care, and equal health outcomes (Culyer 2001; Mooney 1983). Equal access for equal need involves conditions whereby those in equal need have equal opportunities to access health care. This would mean that those who face the same costs when consuming health care also have equal access to health care. Equal utilization for equal need entails conditions whereby those who have an equal need of health care make a similar use of health care. Equality of health as a goal would set numerous restrictions on the ways people want to live their lives. Variations in health outcomes arise from many factors other than the receipt of health care.

According to Culyer and Wagstaff (1993), equality of access does not necessarily lead to the achievement of equality of health or to allocation of health care according to need. Mooney (1983) argues that access is merely a question of supply, while utilization depends on both supply and demand. Individual utilization of health care is possibly affected by many factors that are not connected to health care per se but shape individuals’ demand for health care. Those factors can be incentives, prejudices, preferences, and personal perceptions on benefits associated with the treatment. The last one in part depends on the extent to which people value their health. Hence, the interaction between supply and demand, which depends on characteristics of both patient-consumers and health care providers, results in variations in treatment.

In the literature on health economics, equal access to health care for equal need (especially the principle of equal opportunity) seems to be of more interest (Goddard and Smith 2001; le Grand 1982; Mooney 1983; Mooney et al. 1991; Mooney et al. 1992; Oliver and Mossialos 2004) than equal utilization of health care for equal need (e.g. Culyer et al. 1992; O’Donnell and Propper 1991). The principle of equal utilization does not account for acceptable reasons (e.g. differences in lifestyle preferences) for unequal use of health care. On the contrary, the principle of equal access allows for acceptable reasons (e.g. different individual preferences) why those in equal need with equal opportunities to access to health care may not equally use those opportunities (Oliver and Mossialos 2004). At a practical level, the health policy on equity of most health care systems is normally also defined in terms of access rather than in terms of utilization. However, at the
level of monitoring and measuring equity, measurement has been concentrated much more on utilization of health care. Because it is easier to observe utilization than access, utilization is often used as a proxy for access in most empirical research on equity of access to health care (Goddard and Smith 2001; Oliver and Mossialos 2004).

There are several definitions for access to and need for health care. Access to health care is characterized as receipt of treatment (Tobin 1970), meaning utilization of health care. Access is also considered in terms of money and time costs incurred in obtaining health care (le Grand 1991; Mooney 1983), and further as the maximum attainable level of consumption of health care given the individual’s income and the time and money prices she/he faces (Olsen and Rodgers 1991). Need for health care is defined as health status or ill-health (Culyer and Wagstaff 1993), capacity to benefit from medical care (Culyer 1976; Williams 1974; Williams 1978), and the minimum amount of resources required to exhaust the capacity to benefit from health care (Culyer and Wagstaff 1993).

3.3 Empirical and econometric specifications

Utilization of health care

The utilization of health care is considered as a process consisting of a patient-initiated stage and a physician-generated stage (Stoddard and Morris 1981). Demand is the initial stage of the utilization process where the patient as the sole actor determines the demand for health care. Utilization refers to the entire process, i.e. the sum of both stages, being the amount of care received as a result of decisions jointly made by the patient and the physician. If the agency relationship is perfect, then demand and utilization are identical.

A measure of health care utilization such as the number of visits to a physician or a dentist over a given period of time typically observed in survey data is a discrete and non-negative integer-valued count. Containing a large proportion of zeros, the distribution of that dependent variable is usually skewed to the left and has a long right-hand tail. Characteristically, a large majority of respondents reported no or few visits and only a very small proportion reported a high number of visits. The discrete nature of the dependent variable calls for the application of count data models (e.g. Poisson). However, zero counts and positive counts in survey data on health care utilization are generally considered to come from different distributions of visits. The zeros are not missing but true zeros, and the actual level of use of medical services is the primary interest for prediction purposes (Duan et al. 1984). A high number of zeros reflects the role of the individual’s decision about not seeking care and this choice (the binary outcome of the count being zero or positive) may be governed by a different process than the process determining
the number of visits (the positive counts) once the individual gets into a treatment (Mullahy 1986; Rosenqvist et al. 1995).

The general form of hurdle count regression models for modeling overdispersion or underdispersion of the data was provided by Mullahy (1986). Having applied two-part models for individual utilization of health care, recent empirical research has stressed the two-stage character of the decision-making process of utilization (see e.g. Grootendorst 1995; Pohlmeier and Ulrich 1995). The view was already recognized as the principal–agent relationship between the physician and the patient (Zweifel 1981). That is, once the individual has decided to visit a physician (contact or care seeking decision), it is up to the physician to determine the intensity of treatment (frequency decision). The two-part model assumes that two separate probability processes generate the contact and frequency decisions involved in the utilization process. Therefore, the two different stages of the two-part model can be estimated separately: the first part with a binary process (logit or probit) and the second part with a truncated-at-zero count model. The two-part model has recently been applied to model the utilization of medical services including dental services (see Cameron and Trivedi 1998; Jones 2000 for a general review of count and modified count data models and applications to health care utilization, and Álvarez and Delgado 2002; Sintonen and Linnosmaa 2000; Stoyanova 2004 for a review and applications to dental care utilization).

An alternative model commonly used to model health care utilization is the latent class model (Deb and Trivedi 1997; Deb and Trivedi 2002; Gerdtham 2001). This is argued to be a better framework than the two-part model. It is considered that the division between non-users and users of care is less adequate than the distinction between infrequent (or low) users and frequent (or high) users because the difference between the last two types of users is affected by health status, lifestyle choice, attitudes toward health risk, and personal perceptions (Deb and Trivedi 1997; Deb and Trivedi 2002). In the latent class framework, individuals are drawn from a finite number of latent classes; each latent class represents one type of individuals, while heterogeneity is accommodated within it. The performance of the two alternative models in empirical studies on health care utilization with cross-sectional individual data is not clear; one performs better than the other in some cases (Jimenez-Martin et al. 2002; Winkelmann 2004). The latent class model is also applied to panel data (Bago d’Uva 2005). Moreover, a single, extended model specified in a panel data context that combines both features of the hurdle model and the latent class one is introduced (Bago d’Uva 2006).

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6 The hurdle model has an interpretation as a two-part model. Overdispersion and underdispersion are considered as resulting from a misspecification of the maintained parent data generating process. In this process, the relative probabilities of zero and positive realizations implied by the parent distribution are not supported by the data (Mullahy 1986).
Measures of equality and equity

Most states belonging to the Organization for Economic Cooperation and Development (OECD) to a greater extent finance essential health care services from public sources (Docteur and Oxley 2003). Their governments are committed to ensuring that their citizens have equal access to good quality health care (Hurst and Jee-Hughes 2001; van Doorslaer et al. 1993). Many health care systems thus endorse the principle of equity as a key objective that health care services ought to be allocated on the basis of need and not on willingness or ability to pay.

In international comparisons of health care delivery in different health care systems, most empirical research has focused on the issue of horizontal equity (van Doorslaer and Wagstaff 1992; van Doorslaer et al. 2000; van Doorslaer et al. 2004). As introduced above, this is interpreted to mean that those in equal need of health care ought to be treated equally irrespective of other characteristics. Since systematic differences exist in the treatment of those with similar needs but of different income levels exist, violations of the principle of horizontal equity have been mostly accounted for in terms of income (Wagstaff and Van Doorslaer 2000; van Doorslaer et al. 2000). When addressing the magnitude of inequity in health care that is systematically related to income, one can also identify what particular features of a certain health care system seem to have contributed to different outcomes. This approach uses the utilization of health care to explore equity in health care.

The effects of the distributions of income on the consumption of a market good are often measured by the concentration index (Lerman and Yitzhaki 1989; Shorrocks 1983). This has been developed to construct the so-called horizontal equity index to measure the effects of the distributions of income on health care in terms of financing and utilization, taking into account the need for health care (Gravell 2003; Kakwani et al. 1997; Wagstaff et al. 1991; Wagstaff and van Doorslaer 2000; Wagstaff et al. 2003; van Doorslaer et al. 2000; van Doorslaer et al. 2004). Applying this approach to investigate inequity implies that use of health care should be affected by need variables but not by non-need variables. Inequality in use is viewed as different amounts of health care being used by different individuals. Horizontal inequity in use is regarded as the use of health care that is affected by non-need variables.

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7 Willingness to pay is inevitably based on ability to pay, which in turns reflects the existing distribution of income and wealth.
4 Specific aims and themes of the study

4.1 Aims of the study

The objectives of this study are to empirically examine the factors affecting the utilization of dental care among adult Finns, the effect of the public subsidy scheme on utilization, the factors associated with dental ill-health, and the relationship between dental ill-health and use of dental care, as well as the extent of horizontal equity in utilization. By means of four specific studies, this thesis seeks to answer the following questions:  

i) How do adult Finns use dental services and what is the impact of public subsidization on the utilization of dental services? How does the decision to seek dental care take place under the influence of the provider-offered incentive of recalling? (I)  

ii) Which factors influence the choice of whether to seek dental care, the choice of a public/private dentist and the consumption of sector-specific dental services among those entitled to subsidized dental care on the basis of age? (II)  

iii) Do lifestyle choices, dental health behavior, and socioeconomic variables have effects on dental ill-health measured as the occurrence of caries? Is there a connection between dental ill-health and use of dental care? (III)  

iv) Is the equity objective of dental care policy in terms of utilization of dentist services achieved? Which factors are associated with equity or inequity in the use of dentist services? (IV)  

4.2 Themes of the study

Utilization of dental services

The theoretical model developed by Grossman (1972b) and the previous empirical applications (Hay et al. 1982; Holtmann and Olsen 1976; Pedersen and Petersen 1980) were focused on the individuals’ demand for dental care under perfect information and certainty. Informational asymmetries prevail in dentistry, for example, with respect to the prevalence and the nature of oral disease, the choice of treatment, and the frequency of dental visits. This implies that the role of the supplier is quite important in the demand process.
The reviewed international evidence on the effects of dental insurance, for example, in the USA is not directly relevant to the provision of dental care in Finland. The public and private health service sectors in Finland neither coordinate their activities nor are they real competitors to each other (Järvelin 2002). The NHI reimbursement rate schedule and recommended user fees for dental services charged by the municipal health centers are fixed. Price competition among private dental care providers has been very modest in the 1990s and the early 2000s (Mikkola et al. 2005; Pekurinen 1998). This reflects the fact that ethical issues and practices set up by dentists’ professional associations have generally restrained competition. However, the different payment systems of the dental sectors with differences in cost sharing by patients have provided a provider-offered incentive to encourage regular dental attendance among patient-consumers. Evidence for inducement has been found based on dentists’ recall in Finland (Maljanen 1983; Murtomaa et al. 1994; Sintonen 1986; Sintonen and Maljanen 1995). Generally aimed at dentate people, the recall of adult clients for regular check-ups is a typical form of inducement mainly practiced by private practitioners in Finland. Recall was also found to have an impact on an individual’s decision to contact a dentist in Sweden (Hugoson et al. 1995) and Norway (Grytten 1991; Grytten et al. 1996), where the dental care systems closely resemble that of Finland (Widström and Aaton 1999). The active role of the dentist by means of recall, while being very efficient at stimulating individuals to contact the dentist, also imposes a methodological question on how the demand model could take into account its impact on an individual’s decision to seek care.

Empirical research has identified and discussed the factors that are important to an economic analysis of the demand for dental care (Álvarez and Delgado 2002; Sintonen and Linnosmaa 2000; Stoyanova 2004; Yule and Parkin 1985). It has been shown that the utilization of dental services is related to factors like money and time prices, dental insurance, income, oral health indicators, level of education, age, and supply of dentists per capita. In article I, we explored the factors affecting utilization of dentist services and the role of supply factors in the utilization process. We applied a theoretical model outlined by Sintonen and Maljanen (1995) that was based on the theory of demand for health and dental care (Cooper 1975; Evans 1974; Grossman 1972b; Hay et al. 1982; Keeler et al. 1977; Parkin and Yule 1988). We modeled utilization as a process involving two decisions: one on seeking care from a dentist taking into account endogeneity caused by dentist’s recall and another on the frequency of use. This study was expected to contribute to improved identification and measurement of provider and demander behavior and especially the role of the supply factors affecting the use of dental services.
Choice of dental sector and sector-specific utilization

In examining demand for dental care, there are several features of the market to be taken into account. Dental care is a product that has a multi-attribute nature. Information is imperfect. Public interventions, government regulation, and dentists’ ethical practices are extensive. These measures generally affect competition and the availability of services. As regards dental care in Finland, the market is a two-segment market with each segment having specific characteristics (Table 1). In the face of the two-segment dental service market under imperfect information, consumers have to make decisions among alternatives. In situations where the number of dimensions of choices increases, some decisions have to be made at the same time.

Waiting lists are often used to allocate dental care in the municipal sector. In comparison with municipal dental care, private care gives a care consumer a choice over timing and thus possible avoidance of those waiting lists. It allows the consumer a choice of suppliers and a choice of location and provides a larger range of care services and possibly greater information. As per statute, the specific age group (19–40 years in 1996) had an entitlement to subsidized dental care and to NHI subsidies for private dentists’ treatments at the same time. However, in practice the availability and other market-related reasons (see Table 1) have often affected the choice of which sector to use for dental care. On the demand side, the young generally have little need for dental care. Those fitting the age criterion of the statute have attended health center dentists since their childhood. As they have experienced municipal dental care, they may not have considered private dental care. Some will certainly not have undertaken a detailed comparison between the expected utility related to the two prospects of care (public and private).

Lipscomb and Douglass (1982) introduce a political economic theory of the dental care market, having capitalized on several theoretical constructs. First, the consumption of commodities can and should be considered as the consumption of bundles of commodity characteristics (Lancaster 1966). Second, to decide how to search for a set of utility maximizing purchases, consumers count on market signals that are transmitted by providers (Spence 1972). Third, in a market where consumers demand commodities because of their commodity characteristics, a static equilibrium involving all consumers and providers can be achieved (Rosen 1974). The role of public interventions is connected to Stigler’s (1961) economic theory of regulation and search for information. Accordingly, industries tend to request government policies that support direct subsidies and control over suppression of substitutes, encouragement of complements, price-fixing, and entry of new rivals. On the other hand, consumers’ standard search problems are typically compounded by uncertainty about the market conditions for the product sought, such as price, quality, and availability. Within the framework of a theoretical model of the dental care industry, Lipscomb and Douglass (1982) study the vertical
integrated (local/state/national) structure of the profession. This is proposed as serving an organizational means for expressing and settling professional debate, sharing market information, and attaining favorable regulation.

In empirical studies on consumer choice in health care, theoretical aspects are taken into account to some extent. Traditionally, expected utility theory in combination with demand theory for health care is often relied upon (e.g. Buchmueller 2006 for health plan choice, Cameron et al. 1988 for health insurance choice, and Rodriguez and Stoyanova 2004 for health care provider choice). Choices between public and private health care in the UK (Propper 2000) and choice of dental sector in Finland (Arinen and Sintonen 1994) have also been explored. However, the former considered only choices made on whether to seek care. The latter took specific features of the Finnish dental care system into consideration but focused merely on the choice of sector. Hence, both studies did not allow for further study of the amount of care received from each sector. On the other hand, in addition to the reasons related to institution and market, individual characteristics also have effects on demand for dental care. Results from empirical research have given evidence on income as one important factor associated with the use of specialized health care. Income has a positive effect on access to dental care (Sintonen and Maljanen 1995) and to hospital care (Abasolo et al. 2001; Gerdtham 1997) and on the use of medical specialist services (Pohlmeier and Ulrich 1995). Furthermore, it is positively related to the choice of a medical specialist as opposed to a general practitioner and to the subsequent choice of either public or private specialist (Atella et al. 2004).

In article II, we studied demand for dental care among people entitled to age-based subsidized care, taking into account choices in care underlying individual demand for dental care in the two-segment market. We argued that the existence of the two parallel (public and private) suppliers means that utilization is the outcome of three sequential decision stages. These determine whether an individual seeks care from a dentist, whether the individual selects a public/private dentist, and the amount of care used, respectively. We paid particular attention to the factors affecting the choice of dentist. In the spirit of Grossman’s demand theory, the consumer is assumed to choose which of the two service-sector dentists provides relatively better availability with relatively a lower price of care, all other things being equal.

The demand for dental health

In various studies, dental caries has been found to be significantly associated with financial, socioeconomic and behavioral factors (Bailit et al. 1985; Berset et al. 1996; Chen and Hunter 1996; Cohen and Bryant 1984; Grytten et al. 1996; Petersen 2005; Tala 1983; Thomson et al. 2004). In those very few economic studies, the
Specific aims and themes of the study

determinants of dental health, i.e. caries, are investigated by estimation of reduced-form equations using data sets that generally have health information limited to one period of time. Dental care utilization is often not taken into account in the production function of dental health as an input. Therefore, the direct effect of utilization on dental health is not estimated. Furthermore, the indirect effects of the covariates on dental health via utilization are not examined or elicited. When the indirect effects are ignored, the total effects on dental health of some covariates can be incorrectly estimated.

Article III applied a model that integrates both Grossman’s human capital approach and theories of the household health production function (Contoyannis and Jones 2004; Gilleskie and Harrison 1998). The variables chosen to explore the determinants of dental caries are based on the household health production theory (Grossman 1972a) and findings from earlier studies on the factors that affect both general health (Contoyannis and Jones 2004; Gilleskie and Harrison 1998; Grossman and Kaestner 1997; Kenkel 1995) and dental health (Chen and Hunter 1996; Grytten et al. 1996; Sintonen and Tuominen 1989). To investigate factors affecting the utilization of dental care, we used a simple theoretical model based on the theory of demand for health and dental care described in the study (Sintonen and Maljanen 1995). We chose the independent variables according to both theoretical and empirical studies on health and dental care utilization (Grossman 1972b; Grytten et al. 1996; Hay et al. 1982; Holtmann and Olsen 1976; Sintonen and Maljanen 1995).

Dental health was assumed to be affected by birth weight and variables relating to parental circumstances at time of birth and during youth and by current health and dental health behavior, individual characteristics, dental health stock, and dental care utilization. Utilization was assumed to be associated with individual characteristics, dental health stock, and supply-side factors. This study pointed out the role of health and dental health inputs in dental health production. In addition, since information obtained covers three follow-up points of time, this study was expected to contribute to a better understanding of the relationship between oral health and utilization of dental care as well as to address the association between oral health and education over the life cycle.

Equity in the use of dental services

The need-based use of dental care has been studied by the European Household Community Panel data. The results indicated that inequality and inequity in the use of dental care in most OECD countries, including Finland in 1996 and 2000, were significantly pro-rich (van Doorslaer and Masseria 2004; Xander and van Doorslaer 2004). However, it has been advised that the results be treated with caution due to the lack of information on the need for dental care and on other relevant
Specific aims and themes of the study

Factors in the analysis. Having taken into account more indicators of need, a study that employed the 1997 Spanish Health Survey data also showed significant pro-rich inequity in the utilization of dental services (Stoyanova 2004). Furthermore, concerning inequity in service types, higher income people were significantly more likely to use preventive, restorative, and esthetic dental services than were lower income people. On the contrary, lower income people were significantly more likely to use oral surgical procedures like teeth extractions than were higher income people.9

Inequality in health care can be measured as it stems from inequality posed by different determinants of health care utilization. For the breakdown analysis of total inequality, a well-established methodology decomposes the concentration index by the determinants of health care utilization (see e.g. Wagstaff et al. 2003; van Doorslaer et al. 2004). On the other hand, when a health care measure is additively comprised of components that represent amounts of health care provided by different providers, income-related inequality for that health care measure can be decomposed into components (Clarke et al. 2003; Yao 1999). These two approaches were incorporated to investigate health inequality by socioeconomic determinants in parallel with dimensions of health (Lauridsen et al. 2006).

Article IV added dental care utilization into the analysis of income-related inequality and horizontal inequity, with national health care data having had factors that are more relevant to the need for dental care. To measure inequality and inequity and explain inequality in the use of dental services, we applied the concentration index approach. By decomposing the overall concentration and horizontal equity indices by both dental sector and determinants of dental care utilization, we evaluated how equality or inequality in the use of dental care is related to the specific characteristics of the Finnish dental care system.

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9 In Spain, the public dental sector only provides teeth extractions and in addition diagnostic tests for those during pregnancy.
5 Data and methods

5.1 Data and variable specifications

Articles I, II and IV used data that were based on the 1996 Finnish Health Care Survey. This national survey contains information on socioeconomic and health status and health care utilization among the non-institutionalized resident household population in 1996 (Arinen et al. 1998). A stratified one-stage cluster sampling in which households formed the clusters was applied. Complete data were received from 9037 individuals (of which 80.7% were aged at least 15 years) from 3614 households, corresponding to a response rate of 86.8%. Data on annual income, merged with the health care survey data by means of the official unique personal identification numbers, were collected from register-based tax files maintained by the tax authorities.

In article III, the data were from a follow-up study conducted between 1997 and 1998 that was included in the longitudinal study of the Northern Finland 1966 Birth Cohort (http://kelo.oulu.fi/NFBC). This unselected general population birth cohort included all live births in the provinces of Oulu and Lapland in 1966 (n = 12,058), with data collected since pregnancy. Information on parental socioeconomic and demographic background was collected by questionnaires. Information on pregnancy, births, and newborns was transcribed to study forms by midwives. Data were collected by the health workers in child health centers at age one and by adolescent questionnaires at age 14. The latest postal questionnaire study was conducted in 1997–1998 when the cohort had reached 31 years of age (n = 11,541). The number of eligible replies was 8690, corresponding to a response rate of 75.3%. Data on the mean scores of all school subjects completed at the end of compulsory school (adolescent school achievement) were collected at age 16, whereas data on the highest levels of education completed by age 31 were gathered from the National Education Registry of Statistics Finland.

Table 2 introduces the dependent variables. Appendix A presents the explanatory variables that were used in the empirical models. In article II, the price of a visit to the dentist was measured by five types of cost. They were (a) objective, relative time costs (dentist density; availability of public care for all), (b) subjective view of the price on dentist’s treatment in each sector (expensive public/private care), (c) subjective time costs (sufficient/insufficient public services; sufficient/insufficient private services), (d) time cost incurred by a visit (visit time), and (e) psychological cost (fear). To model the occurrence of caries (III), we also used variables describing current health behavior (lifestyle, health habits, regular teeth brushing (brushing teeth at least twice a day), and use of dental care). In
addition, information relating to time of birth (birth weight, years of schooling of the mother) and to adolescence (father’s socioeconomic status, adolescent school achievement, lifestyle, severe and mild illness) was made used of. While income, dentist density, availability of public care for all, birth weight, years of schooling of the mother, adolescent school achievement, and education were gathered from official registers and statistics, all other explanatory variables were self-reported.

### TABLE 2. Dependent variable definitions

<table>
<thead>
<tr>
<th>Article</th>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Utilization of dentist services</td>
<td>Number of visits to dentists observed in the data</td>
</tr>
<tr>
<td></td>
<td>Care seeking</td>
<td>= 1 if the person visited a dentist in the study year</td>
</tr>
<tr>
<td></td>
<td>Dentist’s recall</td>
<td>= 1 if the person was recalled by the dentist</td>
</tr>
<tr>
<td></td>
<td>Number of visits to the dentist</td>
<td>Number of visits to the dentist for those who had at least one visit</td>
</tr>
<tr>
<td>II</td>
<td>Utilization of sector-specific</td>
<td>Number of visits to the private or public dentist observed in the data</td>
</tr>
<tr>
<td></td>
<td>dentist services</td>
<td>= 1 if the person visited a dentist in the study year</td>
</tr>
<tr>
<td></td>
<td>Care seeking</td>
<td>= 1 if the person visited a private dentist after having decided to visit a dentist</td>
</tr>
<tr>
<td></td>
<td>Choice of a private dentist</td>
<td>Number of visits to the chosen private or public dentist for those who had at least one visit</td>
</tr>
<tr>
<td></td>
<td>Number of visits to the</td>
<td></td>
</tr>
<tr>
<td></td>
<td>private or public dentist</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Dental caries</td>
<td>= 1 if a person reported that s/he had dental caries at the time s/he responded to the questionnaire</td>
</tr>
<tr>
<td></td>
<td>Use of dental care</td>
<td>= 1 if the person had at least one visit to a dentist during the year previous to the data collection time</td>
</tr>
<tr>
<td>IV</td>
<td>Utilization of dentist services</td>
<td>Number of visits to dentists observed in the data</td>
</tr>
<tr>
<td></td>
<td>Utilization of sector-specific</td>
<td>Number of visits to the private or public dentist observed in the data</td>
</tr>
<tr>
<td></td>
<td>dentist services</td>
<td>= 1 if the person visited a dentist in the study year</td>
</tr>
<tr>
<td></td>
<td>Care seeking</td>
<td>= 1 if the person visited a private or public dentist after having decided to visit a dentist</td>
</tr>
<tr>
<td></td>
<td>Number of visits to the</td>
<td>Number of visits to the private or public dentist for those who had at least one visit</td>
</tr>
<tr>
<td></td>
<td>public or private dentist</td>
<td></td>
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</tbody>
</table>

Note. The frequency of visits to dentists was measured during a recall period, i.e. the period of time between the first day of the study year and the interview day. That frequency was modified to represent utilization of a year by a specific risk-day formula (Arinen et al. 1998).
5.2 Methods

Theoretical framework

The utilization of dentist services over a given period of time in a dental care system with two service sectors like that of Finland is proposed to be a three-stage decision-making process involving: (a) contact, (b) choice of a public/private dentist and (c) frequency (Sintonen and Maljanen 1995). The decision to contact a dentist occurs first. Then, subsequent to this initial decision is the decision on which sector (service-sector dentist), public or private. Lastly, the amount of care to be consumed will be decided in terms of the number of visits to the chosen dentist and type of care services per visit (Figure 1). When the dental sectors are not distinguished, the utilization process is viewed as only involving the contact and frequency decisions. In this case, the individual's decision to contact some dentist can be thought of as a joint decision where seeking care from a dentist and choosing the service-sector dentist are made at the same time. If the utilization process is viewed as a combination of both contact and frequency decisions, it is a one-stage decision-making process.

Source: An analytical framework modified according to Sintonen and Maljanen (1995)

FIGURE 1. The decision-making process of utilization of dentist services
Model specifications

To explore factors affecting the utilization of dentist services, we applied a two-part model (I) and a three-part model (II). Both the one-part and two-part models were used to compute indices measuring inequality and inequity and to undertake the decomposition analysis (IV). In article I, ‘dentist’s recall’ and ‘care seeking’ were regarded as two sequential events: an individual could have been recalled by the dentist before she/he went to see the dentist. Therefore, in the first part of the two-part model, the recursive bivariate probit model was applied to model ‘care seeking’ and ‘dentist’s recall’ with the latter also appearing as an explanatory variable in the ‘care seeking’ equation. However, because we could not reject the null hypothesis of a zero disturbance correlation coefficient, we applied a recursive two-equation probit model (hereafter the recursive model) (see Appendix B).

This recursive model approach was also applied to model the occurrence of caries and use of dental care (specified simply as care seeking) with the latter also being used as an explanatory variable in the equation for the occurrence of caries (III). Using the recursive model, we were able to consider the effects of those variables associated with dentist’s recall that were transmitted back to care seeking (I) and similarly the effects of the variables related to use of dental care that had an influence back on dental health (III). Table 3 summarizes the econometric models applied and the data used in the study.

We used the Wald test and the likelihood ratio (LR) test to check the exogeneity of the correlation coefficient in the recursive bivariate probit model (I, III; discussed above). Based on the result from the Chow-type test that was carried out to test coefficient parameter homogeneity, i.e. to check whether we should split the sample in two gender subsamples or not, we estimated the models separately for females and males (I, III). The LR test and the asymptotic \( t \)-ratio for the estimate of the overdispersion coefficient provided tests for us to choose a zero-truncated negative binomial model over a zero-truncated Poisson model (I, II). Concerning ‘caries’ and ‘teeth’ (at least one natural tooth missing), which were both indicators of oral health, we tested the potential endogeneity of ‘teeth’ in the caries equation, using a two-step method equivalent to the omitted variable approach of the Hausman test (III). The test result supported the assumption that ‘teeth’ was free from simultaneity and thus exogenous in the caries equation.

The estimation results were presented as the marginal and total effects of the explanatory variables on the dependent variables (I–III). Because the total effects of the covariates were non-linear combinations of the estimated marginal effects, we applied the non-parametric bootstrap method—the bootstrap that is distribution free—to estimate the standard errors of the total effects (I, III) (Efron and Tibshirani 1993). In addition, we used cross-sectional sampling weights in all computations to make the results more representative of the country’s population and adjusted the standard errors for clustering of households to get robust standard errors (I, II, IV).
TABLE 3. Data and methods applied in the study

<table>
<thead>
<tr>
<th>Article</th>
<th>Data year</th>
<th>n (age in yrs)</th>
<th>Dependent variable or specific purpose</th>
<th>Model specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>I FHCS</td>
<td>1996</td>
<td>4512 (20–92)</td>
<td>Utilization of dental services</td>
<td>A two-part model:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Care seeking and dentist’s recall</td>
<td>1. part: a recursive two-equation probit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Number of visits to the dentist</td>
<td>2. part: a zero-truncated negative binomial</td>
</tr>
<tr>
<td>III NFBC</td>
<td>1997</td>
<td>5020 (31)</td>
<td>Dental caries and use of dental care</td>
<td>A recursive two-equation probit</td>
</tr>
<tr>
<td>IV# FHCS</td>
<td>1996</td>
<td>5375 (14–92)</td>
<td>Utilization of dental services</td>
<td>A one-part model: a linear regression</td>
</tr>
<tr>
<td></td>
<td>2076</td>
<td>(20–40)</td>
<td>Utilization of sector-specific dentist services Care seeking Number of visits to the public or private dentist Income-related equality/inequality Income-related equity/inequity</td>
<td>A two-part model: 1. part: a linear regression 2. part: a linear regression Concentration index Horizontal equity index</td>
</tr>
</tbody>
</table>

FHCS = Finnish Health Care Survey
NFBC = Northern Finland Birth Cohort
* In this article, to estimate the degree of equality and equity in utilization, both the one-part and two-part models were applied for both datasets.

Inequality and inequity

The concentration index (C) is often used to measure relative income-related inequality in the actual use of dental care (in this case). The C index ranges from −1 to +1. If C is negative [negative], there is pro-poor [pro-rich] inequality: lower [higher] income people are more likely to use dental care than are higher [lower] income people. If C equals −1 [+1], all the use of dental care is concentrated in the poorest [richest]. If C is zero, everyone uses the same amount of dental care. The horizontal equity index (HI) is the concentration index that measures the degree of equality in need-standardized use of dental care. When HI equals zero, there is horizontal equity: the amounts of dental care used and needed are proportionally distributed across the income distribution. When HI is negative [positive], it indicates pro-poor [pro-rich] inequity. That is, after controlling for
need differences, lower [higher] income individuals are more likely to have used dental care than are higher [lower] income individuals.

The C index measured the concentration of dental care use by individuals ranked by their income position and weighted by sampling representation (IV). To measure the degree of horizontal equity in use of dental care, the distribution of actual care consumed by the individuals was compared with the expected distribution of care based on need. The variables indicating the overall need for dental care were age, gender, the number of missing teeth, denture, dental pain, time of interview, and unfinished treatment. The utilization of dental services was first modeled by an OLS regression model. Then, the indices measuring inequality and inequity in the use of dental services were estimated. After that, the breakdown of the indices by source of use was carried out. Appendix C introduces methods of measuring inequality and inequity and those of decomposing inequality in the use of dental services.
6 Results

Seeking care from a dentist (I–III)

According to the total effects from the recursive models for both genders (I), the probability of seeking care from a dentist was positively associated with pain and dentist’s recall but was negatively associated with fear and the very high number of missing teeth (Table 4). In addition, while females’ care seeking was positively related to the low number of missing teeth, males’ care seeking was positively related to income. Unemployed men were less likely to seek care than were those employed counterparts.

<table>
<thead>
<tr>
<th>Variable</th>
<th>A priori expectation</th>
<th>Article I</th>
<th>Article II</th>
<th>Article III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Direct effect</td>
<td>Total effect</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Female</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income (in ln)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Unemployed</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full-time worker</td>
<td>+/-</td>
<td>-</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>High education</td>
<td>-/+</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Low number of missing teeth</td>
<td>+</td>
<td>+</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Very high number of missing teeth</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least one natural tooth missing</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fear</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit time</td>
<td>-</td>
<td>-</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Regular dental attendance</td>
<td>+</td>
<td>+</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Dentist’s recall</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Dentist density</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expensive private dentist’s care</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient public dentist services</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4. Factors associated with the probability of seeking care from a dentist

- Hypothetically expected directions of the effects of the explanatory variables on utilization.
- The empirical direction of the effect of the explanatory variable on the dependent variable. + (−) = statistically significantly positive (negative) at least at 5% level.
- The direct effects were from the single probits, whereas the total effects were from the recursive models.
- The results reported here were the direct effects of the covariates.
6 Results

The probability of being recalled by the dentist (dentist’s recall) was positively related to income and the low number of missing teeth (among females) but to age (among males) (I). It was negatively related to unemployment (both genders), to age², the very high number of missing teeth and fear (among males), and to the availability of public care for all (among females). Among males, while the direct effect of ‘unemployed’ on care seeking was negative but not statistically significant, its negative total effect on care seeking was statistically significant and of doubled magnitude (I).

The probability of seeking care from some dentist (II) was positively affected by pain, the low number of missing teeth, dentist’s recall, age, and income (Table 4). It was negatively affected by visit time, expensive private dentist’s care, insufficient public dentist services, fear, and dentist density. Women and students were more likely to contact a dentist.

The probability of being recalled by the dentist (dentist’s recall) was positively related to income and the low number of missing teeth (among females) but to age (among males) (I). It was negatively related to unemployment (both genders), to age², the very high number of missing teeth and fear (among males), and to the availability of public care for all (among females). Among males, while the direct effect of ‘unemployed’ on care seeking was negative but not statistically significant, its negative total effect on care seeking was statistically significant and of doubled magnitude (I).

The probability of seeking care from some dentist (II) was positively affected by pain, the low number of missing teeth, dentist’s recall, age, and income (Table 4). It was negatively affected by visit time, expensive private dentist’s care, insufficient public dentist services, fear, and dentist density. Women and students were more likely to contact a dentist.

Between both genders, the probability of using dentist services (seeking care) was significantly increased by regular dental attendance and having at least one natural tooth missing, and in addition by visit time among females (III). Females who were full-time workers, students, and unemployed had a lower tendency to seek dental care (Table 4). ¹⁰

Choice of a private dentist (II)

The probability of choosing a private dentist as opposed to a public one was positively associated with the perception of insufficient public dentist services, age, dentist’s recall, and the perception of sufficient private dentist services (Table 5). Students and those with the perception of sufficient public dentist services were less likely to choose a private dentist.

¹⁰ The reference category comprised those that had an occupation/profession other than full-time working, student status and unemployed status.
Number of visits to the dentist (I–II)

For both genders, the number of visits to the dentist was positively related to pain and the high number of missing teeth (I) (Table 5). Further, among females it was positively associated with the very high number of missing teeth, visit time and dentist density, whereas among males it was positively associated with the low number of missing teeth, age and the statutory age for subsidized dental care.

Pain also had an increasing effect on the number of visits to both private and public dentists (II) (Table 5). Among users of private care, the number of visits made to the dentist was positively affected by both the low and high numbers of missing teeth, income, and dentist density. Among users of public care, it was positively associated with the perception of public dentist’s care as being expensive.
Factors associated with dental ill-health (III)

According to the estimation results of the recursive models, among females, caries (the occurrence of caries) was positively associated with alcohol consumption, intake of sugar, use of soft drinks, and the body mass index, and it was negatively associated with birth weight, adolescent school achievement, and visit time (Table 6, see Total effect). Among males, having at least one natural tooth missing and the metropolitan domicile had increasing effects on caries, while healthy diet and education had decreasing effects on caries. For both genders, daily smoking increased caries, whereas regular teeth brushing, regular dental attendance and use of dentist services decreased caries.

**TABLE 6. Estimation results from the recursive models for the occurrence of dental caries**

<table>
<thead>
<tr>
<th>Variable</th>
<th>A priori expectationa</th>
<th>Direct effect</th>
<th>Effect on caries</th>
<th>Total effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td></td>
<td>Continuous</td>
<td>Elasticity</td>
<td>t</td>
<td>Elasticity</td>
</tr>
<tr>
<td>Birth weight</td>
<td>+</td>
<td>-0.551</td>
<td>-2.73</td>
<td>-0.551</td>
</tr>
<tr>
<td>Alcohol</td>
<td>-</td>
<td>0.044</td>
<td>2.63</td>
<td>0.044</td>
</tr>
<tr>
<td>Body mass index</td>
<td>+</td>
<td>0.455</td>
<td>2.81</td>
<td>0.455</td>
</tr>
<tr>
<td>Visit time</td>
<td>-</td>
<td>-0.985</td>
<td>-2.69</td>
<td>-0.985</td>
</tr>
<tr>
<td>Adolescent school achievement</td>
<td>+</td>
<td>-0.875</td>
<td>-2.69</td>
<td>-0.875</td>
</tr>
<tr>
<td>Education</td>
<td>-/+</td>
<td>-0.589</td>
<td>-3.04</td>
<td>-0.589</td>
</tr>
<tr>
<td>Sugar</td>
<td>+</td>
<td>16.2</td>
<td>2.75</td>
<td>16.2</td>
</tr>
<tr>
<td>Soft drinks</td>
<td>-</td>
<td>36.2</td>
<td>2.69</td>
<td>36.2</td>
</tr>
<tr>
<td>Healthy diet</td>
<td>+</td>
<td>-8.4</td>
<td>-1.40</td>
<td>-12.7</td>
</tr>
<tr>
<td>Metropolitan domicile</td>
<td>-/-/+</td>
<td>10.1</td>
<td>1.20</td>
<td>15.5</td>
</tr>
<tr>
<td>At least one natural tooth missing</td>
<td>+</td>
<td>12.5</td>
<td>2.10</td>
<td>24.9</td>
</tr>
<tr>
<td>Daily smoking</td>
<td>+</td>
<td>22.9</td>
<td>2.73</td>
<td>19.7</td>
</tr>
<tr>
<td>Regular teeth brushing</td>
<td>-</td>
<td>-20.2</td>
<td>-3.10</td>
<td>-10.7</td>
</tr>
<tr>
<td>Regular dental attendance</td>
<td>-/-/+</td>
<td>-63.3</td>
<td>-7.91</td>
<td>-34.8</td>
</tr>
<tr>
<td>Use of dental care</td>
<td>-</td>
<td>-30.0</td>
<td>-4.82</td>
<td>-38.4</td>
</tr>
</tbody>
</table>

---

* Hypothetically expected directions of the effects of the explanatory variables on the occurrence of caries.
* Since this variable was only used in the caries equation, its total effect on caries was its direct effect.
* Since this variable was only used in the use equation, its total effect on caries was its indirect effect.
* This variable was used in both equations of the recursive model.
Because use of dentist services was assumed to have a decreasing effect on caries, the directions of the total effects of the explanatory variables on caries could be altered and their magnitude could be changed. For example, among females, while the direct effect of visit time on caries was positive (Table 4), its total effect on caries was negative (Table 6). This total effect was only its indirect effect via use of dentist services. Those women who regularly visited dentists had a 75% less occurrence of caries compared to those women who did not regularly visit dentists. Of this total effect, 63% was direct and 12% indirect effect. Among males, education was not statistically associated with use of dentist services, but its decreasing total effect on caries was significant. This suggests that for these male cohort members, the productive efficiency effect of education on dental health was more important than its allocative efficiency effect.

Inequality and inequity in the use of dental services (IV)

For the whole sample, the total number of visits and the probability of seeking care were unequally distributed across income groups. These are expressed by the statistically significantly positive indices C and HI (0.045–0.050) (Table 7). In private care, inequality and inequity were also found in both the total number of visits and the probability of seeking care. As implied by the quite high positive inequity indices (HI = 0.175 and 0.151), the higher income individuals were more likely to contact a private dentist and use private dentist services than the lower income individuals even after need standardization. In public care, pro-poor inequality as well as pro-poor inequity was found in all three measures of utilization. We found pro-poor inequity in the (positive) number of visits to public dentists (HI = −0.036) but equity in the (positive) number of visits both to all dentists and to private dentists (IV).

Among the subsample population (those aged 20–40 years), we found equality and equity in all three measures of dentist utilization. Sector-specifically, in terms of both inequality and inequity, the total number of visits to public dentists and the probability of visiting a public dentist were pro-poor, but those corresponding private measures were pro-rich. Nonetheless, for the young adults, equality as well as equity in both the (positive) number of visits to the public dentist and that of visits to the private dentist was achieved.

For the whole sample, inequality in both the total number of visits to all dentists and the probability of seeking care from a dentist was mainly related to two sources: income and dentist’s recall. In public care, need appeared to be the main driver of both the total number of visits and the probability of seeking care. Public subvention of dental care measured by ‘age20–40’ only had a small effect on

11 In the recursive model, the indirect effect of an explanatory variable on the dependent variable (caries in this case) is the difference between its total effect and its direct effect.
the pro-rich distributions of both the total number of visits to all dentists and the probability of seeking care.

### TABLE 7. Indices describing equality (C) and horizontal equity (HI) in the use of dentist services

<table>
<thead>
<tr>
<th>Variable</th>
<th>Index</th>
<th>Whole sample</th>
<th>Subsample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All dentists</td>
<td>Private dentist</td>
</tr>
<tr>
<td><strong>Total number of visits</strong></td>
<td>C</td>
<td>0.050**</td>
<td>0.219***</td>
</tr>
<tr>
<td></td>
<td>HI</td>
<td>0.047**</td>
<td>0.175***</td>
</tr>
<tr>
<td><strong>Probability of seeking care</strong></td>
<td>C</td>
<td>0.040***</td>
<td>0.203***</td>
</tr>
<tr>
<td></td>
<td>HI</td>
<td>0.045***</td>
<td>0.151***</td>
</tr>
<tr>
<td><strong>(Positive) Number of visits</strong></td>
<td>C</td>
<td>0.004ns</td>
<td>0.022ns</td>
</tr>
<tr>
<td></td>
<td>HI</td>
<td>0.001ns</td>
<td>0.027ns</td>
</tr>
</tbody>
</table>

* p < 0.05, ** p < 0.01, *** p < 0.001  
ns = not statistically significant  
a  When the one-part model was used.  
b  When the two-part model was used.
7 Discussion

7.1 The data, variable measures and methodological issues

Three of our studies employed data from the 1996 Finnish Health Care Survey. This was based on a random sampling design and had a high response rate. Furthermore, the data had information on individual income via linkages to the register-based tax records and relevant factors indicating a need for dental care. Besides, we used cross-sectional sampling weights and controlled for clustering of households in the empirical analyses. The generalizability of the results from articles I, II and IV is limited to some extent due to the exclusion of the institutionalized population from the 1996 national health care survey. However, since this national survey covered the whole population, those results can be considered to provide reliable results on factors associated with the utilization of dentist services and inequalities in utilization.

The high number of missing cases in the 1997 follow-up study included in the longitudinal study of the Northern Finland 1966 Birth Cohort would call for caution in generalizing the findings (III). Because the probability of being included in the study was positively associated with education, those lower educated cohort members outside the study could likely have more unhealthy habits and experience higher levels of caries. Attrition is always a problem in a panel data study, and here with a longitudinal study of 31 years, attrition was unavoidable. However, the problem was carefully examined in another study where the same data were used (Häkkinen et al. 2006). Self-reported caries may be subject to biases relating to the level of information or knowledge of dental diseases, observation, and reporting. Those who did use dentist services during the year prior to the survey presumably had a lower probability of having caries than those who did not. The former were also likely to have detected and reported caries with less bias than those individuals whose last visit to the dentist had been several years previously. This reporting bias might have been related to use of dental care. Similarly, all the variables based on self-reporting in the surveys that were used in the analyses may have included some kind of reporting bias.

The recursive model approach enabled us to allow for the impact of the provider-offered incentive on the individual’s decision to seek care by explicitly modeling the dentists’ recall (I). Likewise, by applying the same model approach the effects on dental ill-health (caries) of the variables associated with dental care utilization that were transmitted back to dental ill-health were taken into consideration (III). Hence, we were able to distinguish the direct and indirect effects of the covariates
on care seeking and both the corresponding effects on dental ill-health as well. This recursive model approach has not been applied before in empirical research on dental care utilization and dental health. On the contrary, the modified count data models (II) and the OLS regression models (IV) were simple and rather ad hoc by nature. As such, the endogeneity of the recall incentive was not taken into account in any part of those models.

The use of cross-sectional data unavoidably entails some concerns relating to the variables chosen. Since the 1996 national survey data had no information on the monetary value of a visit to the dentist, we had to in part measure the cost of a visit by individual perceptions on the sector-specific supply conditions and by subjective views of the price on dental treatment in each sector (II). Nevertheless, it seemed as if the subjective time costs of a visit to the dentist were more likely to reflect the individual’s own experience after having chosen and used the services of the dentist. The significantly positive association between the number of visits to the public dentist and the perception of public care as being expensive was contrary to our a priori expectation. This suggests that once the individuals had decided to seek care and had chosen a service-sector dentist, they accepted care given by the dentist and they continued to be treated by him/her. However, the amount of care used and thus the number of visits they made could be rather high in practice. As a result, the total payment for care could become quite large. Therefore, they could afterwards feel that the treatment received from the dentist was expensive.

Applying the three-part model to study the decision-making process of dental care utilization with the cross-sectional data also seems to be arbitrary to some extent compared to actual practice. First, in reality the first two decisions—the contact decision and the choice of service-sector dentists—are usually made together. Thus, the two-part model of sector-specific utilization (IV) by means of which the C and HI indices were computed seems to be more realistic than the three-part utilization model (II). Second, the principal–agent (patient–dentist) relationship is by nature long-standing. Due to information asymmetries, trust is one important component encompassed by the relationship between dentists and demanders of care. Furthermore, when seeing a dentist, an individual puts efforts in to imparting her/his oral health history to the dentist as well as time and costs incurred from having the overall condition of the patient’s teeth examined. Therefore, once the individual has found a dentist and become the dentist’s patient, she/he may be less likely to change to another.

We assumed that receiving a dentist’s recall means a positive relationship to the previous use of dental services, but we did not know from which sector the recall actually came (II). Using cross-sectional data, we were not able to explore whether changes occurred in the choice of sectors (dentists) and/or in the number of visits to service-sector dentists. Hence, the positive association between dentist’s recall and care seeking (I–II) and that between dentist’s recall and the choice of a private dentist as opposed to a public one (II) seemed to reflect that the sector
(dentist) had been chosen earlier so that recalling a patient to care was possible. This also explains why dentist’s recall had a pro-rich contribution to inequality in both the total number of visits to all dentists and the probability of visiting a dentist for both samples (see IV). Although the use of the three-part model to study the multi-stage utilization process faces disagreement with practice, its application is still useful. Using that model framework, we can easily distinguish the effects of different stages on utilization, especially the effects of variables associated with the choice of sectors.

In our estimation, all self-reported visits observed were assumed to belong to the same course of treatment. An assumption underlying the two-part model is that there is only one sickness spell throughout the observation period. Multiple first contacts to dentists might occur because of multiple dental ill-health spells, which would cause problems with the estimates. If no additional information is available, the first count (contact) in the data might be misclassified and possible multiple first contacts may not be detected. However, the recall period specified for the question on the number of visits to dentists in the 1996 Finnish Health Care Survey was not long and the young cohort adults’ dental health was generally good, implying less care was needed. Hence, the number of cases having multiple first contacts in both data was assumed to be very small.

In the computation of the indices describing inequality and inequity, the individuals’ need for and use of services have been defined according to the chosen sector, public or private (IV). As the covariates were allowed to have different effects in the regressions of sector-specific use, the results from the decomposition analysis showed quite different covariate profiles (signs) in the public and private sectors (see IV). Different cross-sector need for dental care could be explained by sectors’ different clienteles. An increase in the private sector’s supply seemed to enlarge inequality and inequity in the use of dental services consumed by higher income people. On the contrary, an increase in the public sector’s supply seemed to increase inequality and inequity in the use of dental services consumed by the lower income people.

Since the data used were cross-sectional, the econometric models applied were static. As is well acknowledged, dental health and dental care utilization are jointly determined (i.e. dental health influences demand for dental care, but also the use of dental care has an impact on dental health). Furthermore, the relationship between dental care utilization and the development of dental health is by its nature dynamic. These features would call for dynamic models of utilization and dental health and appropriate longitudinal data to better identify the interconnection between dental health and dental care utilization, and to explain variations in the use of dental care and in dental health outcomes. One advantage of longitudinal data would be that we could have studied dental health and utilization with appropriate information

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12 The recall period was defined as the time between the first day of the study year and the interview day. That is, it was from 1.1.1996 until the interview day occurred during 5.4.–21.6.1996 (Arinen et al. 1998).
sets. We could have used lagged dental health status to predict past utilization, thus removing potential endogeneity associated with using current measures of dental health status. We could have also included the lagged dependent utilization variable as a regressor to model current utilization and used lagged dental health status to predict current dental health, capturing state dependence (see e.g. Propper 2000 and Contoyannis et al. 2004).

7.2 The empirical results

The earlier reviewed research on the demand for and utilization of dental care has shown that the institutional settings, the choice of variables and the applied econometric models have varied considerably (Sintonen and Linnosmaa 2000). Since the variables chosen and used in the analyses have also differed, a large variation prevails in the resulting elasticity estimates of key variables such as income, price, and time cost. In addition, descriptive statistics (e.g. means of the variables) for each subsample used in each part of the two-part model were not reported (Arinen 1992), thus making it impossible to compute elasticities from the coefficient estimates that resulted from separate models. However, the verifiable empirical directions of the effects on the utilization of dental services of some main explanatory variables were mostly concordant with our a priori expectations. In congruence with our finding (II), subjective time costs—that is, the personal perception of whether there was easy access to the private sector—were also found to increasingly affect the probability of choosing the private sector (Arinen and Sintonen 1994). Recall was found to increase the probability of seeking care from a dentist (Arinen 1992; Grytten et al. 1996; Hugoson et al. 1995; Sintonen 1986; Sintonen and Maljanen 1995). Moreover, our results indicated that actually dentist’s recall statistically and increasingly affected utilization through its significant effect on the probability of seeking care (I).

Some covariates had empirical effects on the dependent variables in directions that were unclear or counter to our anticipation. For example, visit time was positively associated with female cohort members’ care seeking (III) and with the number of visits to dentists among females (I); this positive direction was not expected. Visit time varied with travel and waiting time, mostly with the former, as an appointment with the dentist is usually made in advance and treatment time is generally fixed. Those females might have had a higher need for care due to deterioration of oral health, which increased the number of visits made and in turn involved more time (visit time) (I). We could also argue that the higher probability of seeking care resulting from higher visit time among female cohort members (III) occurred because the opportunity cost related to their traveling was low.

On the other hand, dentist density had a positive effect on the number of visits to private dentists among young adults (II) and on the number of visits to dentists
among females as well (I) but a negative effect on young adults’ care seeking (II). This negative effect could be partly explained by the low need for care as most of those young adults had a healthy mouth and oral good-health. Since ‘visit time’ was used in the models, the effect of time costs (availability effect) on utilization was controlled. Therefore, the positive association between dentist density and the number of visits (I–II) could be interpreted as evidence of the existence of SID in Finnish dentistry in the light of traditional theory. Based on the estimation results, when both decisions to visit a dentist and select a service-sector dentist were made together, then the effect of dentist density on the propensity of seeking care from a private dentist was decreasing (II). This in turn suggests that the increase in the number of visits to the private dentist associated with higher dentist density was likely to offset the low propensity to seek care within the private sector (II). The same result was found in the previous study on the impact of public subvention on sector-specific utilization of dental care among Finns aged 19–25 years (Arinen 1992).

For lack of information, we ended up using ‘age20–40’ (the statutory age for subsidized dental care) to assess the impact that public subvention of dental care had on utilization. We supposed that when the effect of age on utilization in the models was already controlled by ‘age’ and ‘age’ (I) and by gender and age group dummy variables (IV), that variable could reflect in practice some impact of public subvention on dental care use. We found that public subvention was statistically significantly, positively associated with the number of visits made by males (I). Nevertheless, its positive effect on males’ utilization was not statistically significant at the 5% level (I). Regarding inequality, the results from the decomposition analyses indicate that public subvention contributed little to the pro-rich distribution of the total number of visits to all dentists and to the pro-rich distribution of the probability of visiting a dentist (IV). This suggests that public subvention did not have a strong effect on the use of dental care and on the distribution of need-based use. No strong effect of public subvention on dental service utilization in Finland between 1991 and 1994 was found (Suominen-Taipale and Widström 1998), and no impact of subsidized dental care on utilization among young men in Norway was observed (Grytten et al. 1996).

However, within the context of the development of oral health in Finland, a caution relating to the measure of public subvention would call for another viewpoint. The insignificant effect on utilization of public subvention measured by ‘age20–40’ might have come from the fact that those young adults, while having had good oral health, needed relatively lesser care than the older counterparts owing to the impact of fluoride treatment and use of fluoride-containing toothpaste since their childhood (I). Hence, disparity in oral health between different generations has been probably reflected in different need of care. Nevertheless, even if this
difference in need of care between generations were taken into account, our results relating to inequality and inequity in dental service use would still remain (IV).

The low number of missing teeth had an increasing effect on care seeking (II–III; among females, I) as well as on utilization (I). This positive effect on care seeking of the low number of missing teeth has also been found previously (Suominen-Taipale and Widström 1998). These results were against our expectation as based on Grossman’s theory of the demand for health. Accordingly, a lower stock of oral health (i.e. the high number of missing teeth) is expected to increase the consumption of dental care. Our findings suggest that the lower stock of oral health was likely to reduce the need for care and thus to lower demand for and use of dental care. The lower the number of remaining natural teeth, the lesser the risk of oral depreciation associated with the stock of oral health and the less dental care is demanded. Those with a high number of missing teeth tend to have had a low need to visit a dentist. However, once having visited a dentist, they tend to have had a high need of treatment (I–II, results from the second and third parts of the models) probably relating to specialized or esthetic dental care, for example to restore teeth or/and correct the functioning of dentition. Furthermore, dental care seems to have been consumed to reduce current disutility associated with dental health problems, which was expressed by the significantly positive effect of ‘pain’ (acute need) on utilization (I, II).

A lower prevalence of caries was associated with higher education among male cohort members (III). This finding supports the hypothetical connection between higher education and better health (Grossman 1972a) and is much in line with the results from earlier economic studies (Berger and Leigh 1989; Gilleskie and Harrison 1998; Grossman 2005; Kenkel 1995). On the other hand, the lower prevalence of caries associated with adolescent school achievement among female cohort members supports the hypothetical view that good health is associated with the adolescent cognitive development (Shakotko et al. 1981).

The statistically significant indices explaining inequality and inequity (in absolute values) for both samples were higher for the use of private care than for the use of public care (IV). This implies that both inequality and inequity in use of dental care generally prevailed more in the private sector than in the public sector. The results probably reflected the fact that the ranges of dental services produced by the sectors and the sector clienteles are different and also that there are services offered by the private sector that are not publicly reimbursed. Pro-poor inequality and pro-poor inequity in use of public care could be explained by the fact that municipal dental care and generally publicly supplied dental services in Finland have typically been concentrated on low income people and young age groups. In terms of inequity, we observed a relatively large pro-rich distribution of the total number of visits to private dentists and a relatively small pro-poor distribution of the total number of visits to public dentists among young adults than among the

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14 According to Grossman’s investment model, there is negative relationship between health and health care if the demand for health capital is inelastic (Grossman 1972a).
whole sample population. The results seem to have been associated with the role of different prices of dental services provided by each sector affecting the sector-specific use of services (see II) and to differences in the need for dental care. Public subvention for dental care seems to have had a leveling effect on utilization, which reduced income-related inequality in utilization among young adults. In addition to dentist’s recall, income was largely connected to the unequal distributions of both the total number of visits to all dentists and the probability of visiting a dentist.

There has been concern that the use of the recall system as a marketing device to increase the tendency to seek private care can result in over-treatment and unnecessary costs of treatment, especially to selected well-paid consumers (Mikkola et al. 2007). Equal access to dental services is one of Finland’s key health policy objectives. When only the private practitioners distribute recalls to their clients, unequal receiving of recalls can in effect lead to unequal access to dental care between sector clients. If both sectors’ clients were given the same incentives to contact the dentist, the likelihood of visiting the dentist and thus utilization would probably be higher. This increased utilization might also reflect greater access for the poor, aged and disabled and so forth. On the other hand, from a consumer viewpoint, once having got accustomed to visiting a dentist regularly and thus having teeth regularly checked, many adult patient-consumers actually may demand to be recalled by the dentist. When visiting the dentist and using dental care regularly, oral health problems can be detected and treated early. This may prevent oral health becoming very poor, which can later lead to high costs of treatment for the individual and high dental care expenditures overall. Therefore, utilization based on regular dental check-ups—induced utilization—may be of benefit to oral health and may help to avoid unnecessary costs of treatment.

The relationship between utilization based on recalling and its contribution to the oral health status was not investigated in this study. However, we found that utilization of dentist services (specified as care seeking) reduced caries (i.e. it improved dental health, III). Moreover, dentist’s recall had an increasing effect on utilization through its significantly positive effect on care seeking (I, II). Hence, we can infer that utilization based on dentist’s recall may have promoting effects on oral health (as discussed above). Furthermore, if utilization was measured as expenditure on or cost of using dentist services, on the basis of previous estimation results (I), dentist’s recall would also be a factor likely to increase the probability of visiting the dentist. Besides, we only found pro-poor inequity in the number of visits to public dentists among the whole sample population, but its magnitude (−0.036) was not high. This implies that observed inequity in dentist utilization was largely related to the probability of visiting a dentist. From the viewpoint of society, if the effectiveness of dentist services\textsuperscript{15} is relevant and additional service utilization is worth the economic costs, encouraging both sectors’ clients by means of exactly the same incentive to contact dentists more seems to be justified. Nevertheless,

\textsuperscript{15} We use here the definition posed by Labelle et al. (1994). Effectiveness of dentist services is defined as whether the dentist service positively contributes to the patient’s oral health status or not.
there are certainly some individuals who are reluctant to visit a dentist or do not value sufficiently oral health. To persuade that group of people to visit a dentist regularly, use dental services, and change health behavior toward healthier one would be challenging.
8 Conclusions

We found equity in dentist service utilization among young adults but pro-rich inequity in the total number of visits to all dentists and in the probability of visiting a dentist among the whole sample population. Dentist’s recall seemed to be very efficient at stimulating individuals to seek care and increasing utilization of dentist services. Public subvention for young adults’ dental care did not seem to affect utilization. To enhance equal access to and equal use of dental care across different population and income groups, attention should be focused on supply factors and incentives to encourage people to contact dentists more often. Lowering co-payments and service fees and improving the availability of public services would likely increase dental service use in both sectors, especially among young adults and the people on low incomes. Furthermore, to attain favorable dental health and potential long-term benefits in promoting oral health, appropriate policies and measures aimed at improving dental health education and reducing the detrimental effects of common risk factors on dental health should also be strengthened.

The findings from this study suggest that both the magnitude of equity in utilization measured as e.g. the number of visits to dentists and changes in that magnitude would depend much upon the availability of dental services provided by each sector. However, sector-specific differences in inequity in dental service utilization can be expected to remain as long as the Finnish health care system is a dual-channel financed system. This reflects the fact that patient-consumers in Finland have opted for the sectors to a large extent according to the availability and variety of services supplied by the municipal sector. The two parallel delivery systems with different supplier incentives to patients and dentists have led to the segmentation of the dental care system, where the sectors have actually served different clienteles with different socioeconomic backgrounds. This adverse effect would call for a re-assessment of the reasons for justifying a health care system financed by both public and private channels. In such a segmented service system, the key health policy objective of aiming to provide an adequate access to health care with respect to need for all people would not be easily achievable.

The latest dental care reform implemented in December 2002 in Finland extended the public subsidy scheme for dental care to the entire adult population. In future research, it would be useful to assess how the dental care reform has affected public/private sector choice and sector-specific utilization of dental services. Likewise, one would need to gauge again the equity objective of dental care policy in terms of utilization and/or in terms of dental health. In the case of the former, more insight into equity in the utilization of dental services would be gained if the same services and procedures provided by both sectors were taken into consideration. Future research should also pay attention to data used. Appropriate
panel data would be of advantage not only to capture the dynamic nature of dental care utilization and oral health status, but also to avoid many of the estimation problems entailed by cross-sectional data.
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Appendix A

Some main independent variables used in the empirical analyses

<table>
<thead>
<tr>
<th>Variable</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IVa</th>
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</thead>
<tbody>
<tr>
<td>Individual characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (age of the person in years)</td>
<td>cv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Age²/100 (age of the person squared in years)</td>
<td>cv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low education (&lt; 10 years of schooling)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>High education (&gt; 12 years of schooling)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Education (years of schooling)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Income (in (\ln))</td>
<td>cv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Unemployed</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Full-time worker</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Student</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low number of missing teeth (1–5 missing teeth)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>High number of missing teeth (6–10 missing teeth)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Very high number of missing teeth (&gt; 10 missing teeth)</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least one natural tooth missing</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malocclusion</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denture (using a removable prosthesis)</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fear (considering visits to the dentist very/quite frightening)</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain (suffering from toothache or dental problems)</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visit time (total time in hours required for a visit to the dentist, including travel, waiting and treatment time)</td>
<td>cv</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Regular dental attendance (visiting a dentist at least once every two years)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
### Variable Article

<table>
<thead>
<tr>
<th>Variable</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitan domicile (residing in the metropolis of Helsinki, Espoo, Kauniainen and Vantaa)</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provider’s characteristics or supply factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 20–40 (those aged between 20 and 40 years)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Dentist’s recall (being recalled by the dentist)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Dentist density (number of dentists working in each health center district per 1000 residents)</td>
<td>cv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Availability of public dental care for all</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Expensive public dentist’s careb</td>
<td>dv</td>
<td>x</td>
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<td></td>
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<tr>
<td>Expensive private dentist’s careb</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>Sufficient public dentist servicesb</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>Insufficient public dentist servicesb</td>
<td>dv</td>
<td>x</td>
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<td></td>
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<tr>
<td>Sufficient private dentist servicesb</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insufficient private dentist servicesb</td>
<td>dv</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of interview (in ln)</td>
<td>cv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Unfinished dental treatment (at the time of interview)</td>
<td>dv</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

* Dummy age group variables for both genders were used.

b Respondents’ subjective view or perception on the question introduced.

x = the explanatory variable that was used in the empirical analysis.

cv = continuous variable
dv = dummy variable
Appendix B

The bivariate probit model and the two-equation probit model

The bivariate probit model applies to a pair of binary dependent variables with correlated disturbances (Greene 2000; Maddala 1983). The model is estimated by full information maximum likelihood (FIML). The recursive specification is addressed if one dependent variable appears as an explanatory variable in the other equation. As applied in article I, dentist's recall also appears as an explanatory variable in the ‘care seeking’ equation. The correlation coefficient $\rho$ measures the correlation between the disturbances $\varepsilon$ and $\mu$ in the equations $y_c$ (care seeking) and $y_r$ (dentist’s recall) (Figure 2). The asymptotic $t$-ratio for the estimate of the correlation coefficient $\rho$ provides a test for exogeneity. Under the null hypothesis of $\rho = 0$, the recursive bivariate probit model turns into a recursive model of two single probit equations. That is, if $\rho$ equals zero, the equations are actually unrelated by the disturbances. In this case, the log likelihood of the recursive model is the sum of the log likelihoods for the two independent probit equations, which can be estimated separately by the maximum likelihood (ML).

Regardless of the test result of the null hypothesis of $\rho$, in this recursive model, an explanatory variable $x$ that is used in both equations $y_c$ and $y_r$ typically has two kinds of effects on the dependent variable ‘care seeking’. The first one is a direct effect produced by its presence in the equation $y_c$, and the second one is an indirect effect through the equation $y_r$. The sum of these two parts is the total effect of $x$ on ‘care seeking’. (Note: in Figure 2, $z$ is an independent variable that only appears in the equation $y_c$.)

![Figure 2. The recursive bivariate probit model specified to model care seeking ($y_c$) and dentist's recall ($y_r$) and the connection between the two variables](image-url)
Appendix C

Measuring inequality and horizontal inequity and decomposing inequality in the use of dental services

One particular feature in the present study (Article IV) is the decomposition of the concentration index made simultaneously by explanatory variable and by dental sector. The decomposition method by determinant of health care utilization is illustrated in some studies (Gravell 2003; Lerman and Yitzhaki 1989; Shorrocks 1983; Wagstaff et al. 1991; Wagstaff and van Doorslaer 2000; Wagstaff et al. 2003; van Doorslaer et al. 2004; van Doorslaer and Masseria 2004; van Doorslaer et al. 2000), and by component of health care from other studies (Clarke et al. 2003; Yao 1999). Below is a brief description of the methods used.

Measuring income-related inequality

Let \( I_i, y_i \) and \( w_i \) be individual income, the amount of dental care and the sampling weight of the \( i \)th individual in a sample of \( N \) observations. A formula for calculating the concentration index \( C \) for \( y_i \) using weighted data is

\[
C = \frac{2}{N\mu} \sum_{i=1}^{N} w_i (y_i - \mu)(R_i - \frac{1}{2}) = \frac{2}{\mu} \text{cov}_w (y_i, R_i)
\]

where \( \mu = (1/N) \sum_{i=1}^{N} w_i y_i \) denotes the (weighted) mean use of dental care of the sample, \( \sum_{i=1}^{N} w_i = N \) and \( \text{cov}_w \) is the weighted covariance. \( R_i \) is the weighted relative fractional rank of the \( i \)th individual in the income distribution defined as

\[
R_i = \frac{1}{N} \left( \sum_{j=1}^{i-1} w_j + \frac{1}{2} w_i \right) \quad \text{where } w_0 = 0.
\]

Alternatively, \( C \) can be computed using a regression approach:

\[
(2\sigma^2_{R_i}/\mu) y_i = \delta_0 + \delta_i R_i + u_i
\]

where \( \sigma^2_{R_i} \) is the weighted covariance of \( R_i \). The estimated coefficient \( \hat{\delta}_i \) equals \( C \), and its standard error provides the estimated standard error of \( C \).
Decomposing income-related inequality

If \( y \) is additively composed of \( J \) components provided by different providers such that \( y = y_1 + y_2 + \ldots + y_J \), the overall concentration index \( C \) for \( y \) can be decomposed as

\[
C = \sum_{j=1}^{J} v_j C_j
\]

where \( v_j = \mu_j / \mu \) is the weight or the share of \( y \) the \( j \)th component represents, \( \mu_j \) is the mean use of the \( j \)th component, and \( C_j \) the corresponding concentration index.

Assume that \( y \) has a demand function, a linear additive regression model specified as

\[
y_i = \alpha + \sum_{k=1}^{K} \beta_k x_{ik} + \varepsilon_i
\]

where \( \alpha \) and \( \beta_k \) are coefficients, \( x_{ik} \) is a set of \( K \) exogenous determinants and \( \varepsilon \) an error term. Then \( C \) can be decomposed into contributions of determinants as

\[
C = \sum_{k=1}^{K} (\beta_k x_k / \mu) C_k + GC_\varepsilon / \mu
\]

where \( x_k \) and \( C_k \) are the mean of the \( k \)th variable and the corresponding concentration index (defined analogously to \( C \)). The weight or the share \( \beta_k x_k / \mu \) is the elasticity of \( y \) with respect to the \( k \)th variable evaluated at the sample means and \( GC_\varepsilon \) a generalized concentration index for \( \varepsilon \). The decomposition (6) can be specified as consisting of a total predicted concentration index \( \hat{C} \) and a residual term \( GC_\varepsilon \):

\[
C = \sum_{k=1}^{K} \hat{\eta}_k \hat{C}_k + GC_\varepsilon / \mu = \hat{C} + GC_\varepsilon
\]

where \( \hat{\eta}_k \equiv \beta_k x_k / \mu \) denotes the estimated demand elasticity of the \( k \)th variable and \( \hat{C}_k \) the corresponding concentration index.
Component decomposition vs. determinant decomposition

For each component $j$, equations (5) and (7) can be defined similarly as

\begin{equation}
 y_{ij} = \alpha_j + \sum_{k=1}^{K} \beta_{jk} x_{ik} + \epsilon_{ij}
\end{equation}

\begin{equation}
 C_j = \sum_{k=1}^{K} \left( \frac{\hat{\beta}_k x_k}{\mu_j} \right) \hat{C}_k + GC_{ij} = \hat{C}_j + GC_{ij}.
\end{equation}

Inserting (9) into (4) will lead to

\begin{equation}
 C = \sum_{j=1}^{J} \frac{\mu_j}{\mu} \left( \sum_{k=1}^{K} \frac{\hat{\beta}_k x_k}{\mu_j} \hat{C}_k + \frac{GC_{ij}}{\mu_j} \right) = \sum_{j=1}^{J} \frac{\mu_j}{\mu} \hat{C}_j + \sum_{j=1}^{J} \frac{GC_{ij}}{\mu} = \hat{C} + GC_{e}.
\end{equation}

Both equations (7) and (10) present $C$ as consisting of two components. However, in equation (10) the deterministic component is a weighted sum of concentration indices of $K$ variables across $J$ components and the residual component is a sum of different component residuals. Because the predicted concentration index for the $j$th component $\hat{C}_j$ and the total residual $GC_{e}$ are orthogonal, the latter equals the sum of all component residuals $\sum_{j=1}^{J} GC_{ij}$. Thus, the two decomposition approaches (7) and (10) are equally the same. This can be seen from writing equations (7) and (10) as

\begin{equation}
 C' = \sum_{k=1}^{K} \frac{x_k}{\mu} \hat{C}_k \hat{\beta}_k + \frac{1}{\mu} GC_{e}
\end{equation}

\begin{equation}
 C' = \sum_{k=1}^{K} \frac{x_k}{\mu} \hat{C}_k \left( \sum_{j=1}^{J} \hat{\beta}_k \right) + \sum_{j=1}^{J} \frac{GC_{ij}}{\mu}.
\end{equation}

Measuring horizontal inequity

For measuring inequity, the index below has been proposed:

\begin{equation}
 HI = C - \hat{C}_{need}
\end{equation}

where $\hat{C}_{need}$ denotes the concentration index corresponding to the need for dental care. This is computed using predicted use of dental care.
Assume that $x_k$ consists of income ($I$), a vector of need standardizing variables $x_s$ and a vector of other variables of interest $x_p$. Equation (7) can be equally expressed as

\begin{equation}
C = \hat{\eta}_i \hat{C}_i + \sum_{s=1}^{S} \hat{\eta}_s \hat{C}_s + \sum_{p=1}^{P} \hat{\eta}_p \hat{C}_p + G \hat{C}_e
\end{equation}

This equation provides an alternative way to calculate the index HI, which is equal to the sum of the first, the third and the fourth terms. Equally, equation (11) can be written as

\begin{equation}
HI = C - \sum_{s=1}^{S} \hat{\eta}_s \hat{C}_s.
\end{equation}

The decompositions (12) and (13) can be applied to measure inequity in dental care for component $j$. Similar to the decomposition (4), HI can be decomposed as

\begin{equation}
HI = \sum_{j=1}^{J} v_j HI_j
\end{equation}

where $HI_j$ is the horizontal inequity index for component $j$.

Equation (5) is used to generate the need-predicted use of the $i$th individual $\hat{\gamma}_i^X$. This use indicates the amount of dental care he/she would have received if he/she had been treated as the others with the same characteristics of need. It is estimated as

\begin{equation}
\hat{\gamma}_i^X = \hat{\alpha} + \hat{\beta} x_i + \sum_{s=1}^{S} \hat{\beta}_s x_s + \sum_{p=1}^{P} \hat{\beta}_p x_p
\end{equation}

where $x_i$ and $x_p$ are the sample means of $x_i$ and $x_p$. The estimate of indirectly need-standardized use of dental care, $\hat{\gamma}_i^{IS}$, is defined as

\begin{equation}
\hat{\gamma}_i^{IS} = \gamma_i - \hat{\gamma}_i^X + \mu.
\end{equation}

Need-predicted use and need-standardized use of component $j$ for individual $i$, $\hat{\gamma}_i^X$ and $\hat{\gamma}_i^{IS}$, can be computed by applying equations (15) and (16) for that component.