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Dental Health Care Cooperating with Primary Health Care as a Resource in Early Case Finding of Patients with Diabetes or Hypertension

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Abstract
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Objectives To investigate if there is an association between dental health status and high blood pressure, to test the effectiveness of screening for high blood pressure and high blood glucose performed by the dental health care in collaboration with primary health care and to investigate the direct costs for this type of screening organisation.

Study population and methods In Paper I 54 subjects with known hypertension and 141 with a high blood pressure in the dental office were compared with matched controls. In Paper II 1,149 subjects were screened for hypertension and in Paper III 1,568 subjects were screened for diabetes in dental care. Follow up was performed in co-operating primary health care centres. In paper IV the direct costs for screening and follow-up were calculated.

Results There was a significant association between deep periodontal pockets and high blood pressure, even when the influence of age, sex, smoking and number of teeth was taken into account. Among those being screened for high blood pressure and high blood glucose 20.6% and 9.9% respectively were referred to primary health care, and a hypertension or a diabetes diagnosis was found in 32.1% and 5.8% of those screening positive. For every 18th subject screened a hypertension case was found ("numbers needed to screen" (NNS)), and for every 196th a diabetes case. NNS for combined hypertension and diabetes screening was 15. The total direct costs for screening and follow up per diagnosis found were 5,298 SEK for hypertension, 19,100 SEK for diabetes, and 4,116 SEK for combined blood pressure and blood glucose screening.

Conclusions There was an association between dental health and hypertension. Screening for hypertension was highly efficient, while screening for diabetes was less so, because it is a less prevalent condition. Screening for both conditions appears to be the most efficient type of screening.

Keywords: Screening, dental care, primary health care, high blood pressure, high blood glucose

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To my beloved family

List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.

I Engström S, Gahnberg, L, Högberg H, Svärdsudd K. (2007) Association between high blood pressure and deep periodontal pockets. *Upsala J Med Sci* 112;95:103.

II Engström S, Berne C, Gahnberg L, Svärdsudd K. (2011). Efficacy of screening for high blood pressure in dental health care. *BMC Public Health* 11:194.

III Engström S, Berne C, Gahnberg L, Svärdsudd K. Effectiveness of screening for diabetes mellitus in dental health care. Submitted.

IV Engström S, Borgquist L, Berne C, Gahnberg L, Svärdsudd K. Costs of screening for hypertension and diabetes in dental care and follow up in primary health care. Manuscript.

Contents

Prologue

I became a dentist in 1979 at Karolinska Institutet and in 1980 I moved from Stockholm, Sweden, to Gävle, the administrative centre of Gävleborg county, Sweden. After a while I become responsible for one of the dental care clinics in the Public Dental Service. As a dental care representative I became engaged in issues of collaboration in the County Council, and had the opportunity to meet professionals from various parts of the health care sector regularly. Over time, issues related to collaboration gained higher priority in our work. For example, projects were initiated in which dieticians using problem-based learning to support the work of a number of dental hygienists, anti-tobacco use work was intensified and conditions relating to children and young people came more and more into focus through our shared processes.

In 1985, a community based cardiovascular disease intervention programme was established in Norsjö, Västerbotten county. A dental clinic in the city of Gävle started a small project based on ideas from the Norsjö programme 1997. Experience from the Norsjö programme led to further discussions about developing the dental care clinic project into an opportunistic screening study in Gävleborg county. An important prerequisite was that a high percentage of individuals in the county regularly attend the dental care clinics for annual or biannual check-ups even when healthy and free from symptoms.

I have long nurtured an interest in public health, and with financial support from the Gävleborg County Council I completed a Master of Public Health degree at Linköping University, after which I worked with public health issues in the Public Dental Service. I continued to develop the idea of screening for cardiovascular disease risk factors and diabetes at dental care clinics and contacted the Centre for Research and Development Uppsala University/ Gävleborg County Council. At the time, the project idea was controversial, but interested colleagues and the heads of the Public Dental Service and Centre for Research and Development Uppsala University/Gävleborg County Council, and most importantly, the chief physicians in primary health care in Gävelborg county, saw an opportunity to use dental care for screening and were interested in supporting the study concept.

We knew that some dental care clinics were already active in screening for high blood pressure and high blood glucose, but to our knowledge no scientific research about the effectiveness of such screenings programmes had been carried out. When my supervisors Kurt Svärdsudd, Christian

Berne, and Lars Gahnberg entered the project group, all the pieces fell into place and a fantastic journey towards a new field of collaboration started.

This thesis is part of a development that I hope will continue, and perhaps be implemented as standard procedure. Preventive care and health promotion are great challenges of the future. Health strategies are needed for the general population as well as for those at high risk of disease. In this thesis an effort has been made to apply the high risk concept in a dental care/primary health care co-operation project.

Introduction

High blood pressure

Hypertension is a global health problem and is one of the risk factors that contributes most to the burden of disease among both men and women [1]. However, since the condition is virtually without symptoms, it is usually discovered at random when the person is seeing a physician for other reasons, a sort of non-systematic screening. In Europe the 'rule of halves' has been discussed, meaning that only half of all subjects with hypertension are under treatment for the condition, and only half of those on treatment have blood pressure levels in accordance with the guidelines [2-5].

In recent years an improvement has been found. In the US, approximately 70 % of adults with hypertension are aware of it and about 60% of individuals with high blood pressure are on treatment [6].

Non-invasive blood pressure measurements are traditionally performed using the Korotkoff – Riva-Rocci method, requiring a cuff, a manometer and a stethoscope. In recent decades blood pressure automats have been developed, providing blood pressure readings of a quality similar to manual readings [7].

The consequences of untreated high blood pressure induced increased risks of developing organ damage, including myocardial infarction, congestive heart failure, stroke, kidney disease, widespread atherosclerosis, and retinopathy [6]. There is a general consensus that the best ways to avoid such problems are early detection and treatment before organ damage has occurred.

During the last fifty years, blood pressure control in the general population has improved, resulting in lower blood pressure levels among those treated. Moreover, the blood pressure among subjects with non-hypertensive systolic blood pressure levels has decreased by more than 10 mmHg during the period [8, 9]. The reasons for this decrease are so far unknown, but have been claimed to be attributable to change in diet from, a traditional Northern European to a Mediterranean style [10, 11].

As a consequence, the incidence of hypertension-related organ damage has decreased. This decrease is most consistently reported for myocardial infarction and stroke. Myocardial infarction incidence and mortality increased in Sweden until 1979-1981, then entered a decreasing trend, with a nation-wide decline of myocardial infarction incidence, and mortality of

more than 40% among men and women of all age [12, 13]. Similar changes have taken place in other countries as well [6, 14-16].

However, despite progress in prevention, detection and treatment, hypertension remains a major public health problem and it has been estimated that approximately 27% of adults in Sweden, of whom one third still may be undetected may have hypertension, according to WHO criteria [17]. There is thus still a need for screening, case-finding efforts, and other preventive activities.

Diabetes mellitus

Diabetes mellitus is also a global health problem [18]. The incidence and prevalence exhibits considerable variation between countries [19]. In Sweden the diabetes mellitus prevalence is approximately 3-4% [19-21] but it is estimated that more than one third of those with diabetes mellitus have not yet been identified [22, 23]. The prevalence seems to be on the rise because of decreasing mortality among subjects with diabetes mellitus, while the incidence appears to be rather stable [20, 24].

Diabetes mellitus is a complex chronic metabolic disease with multiple aetiologies, involving environmental and genetic factors. The diabetes mellitus classification includes type 1 and type 2, genetic disorders of insulin secretion, and secondary diabetes mellitus [25]. The latter is a rare consequence of other conditions, such as malignancies, with severe damage to the pancreas. Type 1 is caused by insulin deficiency, in turn caused by immunology-mediated destruction of the islet cells in the pancreas. Type 2, which is the diabetes mellitus form of interest in this thesis, is associated with impaired insulin sensitivity in peripheral tissue leading to increased insulin production and, finally, an inability of the pancreas to respond to demands, with inadequate insulin secretion as a consequence. In the following text diabetes refers to diabetes mellitus type 2.

Like hypertension, diabetes has few if any early symptoms, and the disease may therefore go undetected for many years. The latently period, *i.e.*, from the start of the disease to a clinical diabetes diagnosis, has been estimated to 4 – 7 years [26]. Furthermore, there is substantial overlap between the presence of hypertension and type 2 diabetes [27, 28]. Untreated diabetes is associated with complications such as increased risk of neurologic, renal, cardiovascular disease, and oral disease [29]. Epidemiological and prospective studies have shown benefits of early detection and that early glycaemic control may reduce the risk of diabetes complications [30-33]. Prevention of complications will not only benefit patients, it also has the potential to reduce overall health care expenditure [34, 35]. On the other hand some studies point out that direct evidence is lacking about the health outcome in the long-term perspective [36, 37].

Blood glucose is usually measured in capillary blood, which is also suitable in screening or case-finding studies [38]. Blood glucose measurement has, during the last decade, been replaced with plasma glucose. Screening and case-finding are usually based on non-fasting blood or plasma glucose. Several simple test devices have been developed, such as the Hemocue B-glucose analyser (Hemocue AB, Sweden) and the Accu-chek Compact device (Roche Diagnostics Scandinavia AB, Sweden) used in this study, allowing glucose testing in primary health care and dental care clinics.

HBA1c, a measure of the average plasma glucose concentration over prolonged periods of time, has also been used for diabetes screening, although there is insufficient evidence about its validity in screening. However, it may be a specific, convenient future alternative to blood glucose measurement for diabetes screening [39]. The possibility of diabetes screening in the dental care system using crevicular blood from the tooth pocket, has also been tested, but the technique to obtain an acceptable blood sample from gingival crevices has been found to have doubtful feasibility for blood glucose measurement, limiting its application for clinical practice use [40].

Oral health, hypertension, and diabetes

Hypertension, diabetes, and smoking are important risk factors for cardiovascular disease [6, 41] and have also been associated with oral health. However, although it is still unknown whether the association to oral health is of a causal nature, hereditary and lifestyle are certainly important influencing factors [6, 42-52]. Smoking is one of the strongest risk factors for periodontal disease [46].

Chronic inflammation has been in focus when searching for an explanation of the association between cardiovascular disease and dental disease, such as periodontitis, a chronic disease with multi-factorial aetiology and usually slow development with few symptoms. It is induced by oral bacteria, and, left untreated, the condition leads to destruction of the connective tissue and bone supporting the teeth [53-57]. The clinical diagnosis requires evaluation by a dentist or dental hygienist.

Periodontitis begins with an inflammation in the gingival tissue and if the bacteria, that adhere to each other on a tooth surface to form a bio-film, are not removed, gingivitis will sooner or later develop. Why gingivitis progresses to periodontitis in some cases but not in others is unclear. It might be influenced by host responses to the microbial challenge [58]. Although poor oral hygiene is often regarded as the reason for deep periodontal pockets that remain inflamed after local treatment, the possibility that it might, to some extent, be attributable to deficient general health should not disregarded [59].

Pocket depth is a commonly used measurement for identifying periodontal disease. However, there are some concerns regarding the validity and

reliability of dental pocket depth measurements [60]. A pocket depth of 3 millimetres is considered to be within normal limits, 4 millimetres is considered borderline, while a pocket depth of 5 millimetres is usually regarded as an indication of disease. It has been shown that moderate to severe periodontitis increases the level of systematic inflammation as well [61, 62].

The risk of periodontitis among diabetes patients is twice as high as among non-diabetic subjects [63] and diabetes patients with poor metabolic control have more clinical tooth attachment loss than those with satisfactory metabolic control and healthy referents [47, 64-66] indicating that diabetes increases the risk of contracting periodontitis. However, the causal relationship between diabetes and periodontitis is unclear. In a large US survey, patients with periodontal disease developed diabetes type 2 to a larger extent than those with no periodontal disease [67], indicating that periodontitis increases the risk of contracting diabetes. The biological mechanism is not fully understood, but the immune system and inflammation could be common links as they are both involved in diabetes and periodontitis [68].

Moreover, chronic diseases, such as periodontal disease, have negative effects on the degree of metabolic control in diabetes subjects. Treatment of chronic periodontal infections is essential in the diabetic patient and is fundamental to the ability to make appropriate treatment decisions [63, 69]. Caries, another dental health problem, is closely associated with many risk factors, such as improper diet and disease provoking lifestyles. Lifestyle can be a result of other conditions and vice versa, and caries may therefore be an indicator of poor general health [70, 71].

Health promotion

Health promotion implies enabling people to gain control over their health [72]. It extends beyond a focus on individual behaviour towards a wide range of social and environmental interventions. Oral health is part of total health, and is also essential to quality of life [73]. This assumes both that there is room and opportunity for individuals to influence their situation, and that social conditions essential to good health may be monitored and improved [74].

Prevention

Preventing disease involves a wide range of interrelated programmes, actions, and activities and may be classified into three different forms. The definitions vary somewhat depending on field of preventive area. Generally, primary prevention is focussed on avoiding the causes of the disease, secondary prevention aims at detecting disease in its early stages, when it is

asymptomatic and treatment to halt progressing is possible, and tertiary prevention aims at preventing further deterioration or reducing complications after the onset of the disease [74, 75]. In medicine, primary prevention is usually defined as actions directed towards those at risk of contracting a disease or who are in the very early stages, while secondary prevention is directed towards those who had a first spell of the disease to prevent recurrences, and tertiary prevention is directed towards the social consequences of the disease. An alternative term used for primary prevention in those who are in the early stages of a disease is case-finding.

"The Fourth Joint European Societies Recommendation on Prevention of Coronary Heart Disease in Clinical Practice Guidelines" [76] and "the Swedish National Guidelines for Diabetes Care" [77] emphasis the importance of early detection of risk factors, such as high blood glucose and high blood pressure. The new Swedish National Guidelines for Disease Prevention Methods from 2011, issued by the Swedish National Board of Health and Welfare, contain recommendations on methods to prevent diseases by supporting healthy life style choices. They also point out that lifestyle diseases are major contributors to the overall disease burden in Sweden [78].

Preventive care to avoid diseases, assumed to be potentially reversible in the early stage, has become a growing priority for both international and national health institutions [78-80]. Important impact factors for this standpoint are knowledge about the suffering caused by the disease, its complications and the growing costs of treatment [81]. The outcomes of these diseases seem to be influenced by early detection and treatment, which is in focus for the World Health Organization (WHO) emphasis on the importance of health promotion and preventive work. It is also the focus of the Swedish government declaration in the Public Health Policy Objectives that a more health promoting and disease preventative perspective should permeate all health services and be a given part of all care and treatment [82]. The Public Health Policy Objectives also acknowledge the role of primary health care as important in these health promotion efforts and this preventive work.

Preventive care has often focused on one risk factor at a time, but it seems that common predisposing factors tend to occur simultaneously in the same individual, and that some chronic diseases share risk factors with various others [27, 70]. Some researchers have therefore pointed out that it is appropriate to focus on risk factor conglomerates, such as the metabolic syndrome which includes components like abdominal adiposity, high blood pressure, high blood glucose, peripheral insulin resistance, and high blood lipids [27, 41].

Two main prevention strategies have emerged. One is the population approach, which means that the preventive activities are performed in the entire population, for instance vaccination programmes. The other is the high-risk strategy, focused on the fact that some individuals are more vulnerable to disease than others, because they have a higher risk factor level [70, 83]. Pursuant to this strategy various types of screening procedures are used to identi-

fy such individuals. The most optimal approach in prevention is a combination of the population approach and the high-risk strategy, where possible.

Prevention programmes

Ever since the 1960s there have been discussions about various forms of community-oriented preventive programmes to combat cardiovascular diseases [84]. One of the first large-scale programmes of this type was in North Karelia County in Eastern Finland with the neighbouring Kuopio County as reference area [14]. According to the programme, a large number of facilities in the county were used to improve lifestyle of the population. The programme was initiated in the 1970s and was carried out over next 20 years. At the end of the programme the myocardial infarction incidence in North Karelia had fallen from being the highest in Finland to being close to the national average [85].

The North Karelia project inspired similar programmes in other parts of the world. In Sweden, two similar programmes were initiated, one in Västmanland County [86] and one in Västerbotten County [84]. In Västerbotten County the idea of using a population strategy and a systematic screening for risk factors gave rise to the "Norsjö project",which was initiated in 1985. The rationale was the same as in Finland, the high incidence of cardiovascular disease in Northern Sweden. The project was based on collaboration between the primary health care system and other actors. In the programme, primary health care was an important partner, but other efforts also were made to raise public awareness on health issues in the municipality. For example, a new food labelling system for healthy choices was introduced in the grocery stores, which later become the official Swedish food labelling system called 'the keyhole' [84, 87].

The "Norsjö project" was later expanded and the name changed to "The Västerbotten Intervention Program". The simple strategy is to offer a health examination with an accompanying health-discussion to all residents in the age of 40, 50, and 60 years [88]. It was shown that participating in health screening that included motivational dialogue resulted in a lower incidence of cardiovascular disease and diabetes during the following eleven years, as compared with health screening with no health dialogue [89]. This lifestyle change can positively influence the development of these diseases [90-92], and early detection of a risk may also give possibilities for pharmaceutical treatment when necessary.

In Gävleborg County, a cardiovascular disease prevention programme based on primary health care has been running since 2001. According to the programme, all residents are invited for a health dialogue at 40 years of age, where blood pressure and plasma glucose monitoring are performed [93]. Of those invited, about 41% participated in 2010.

Screening

The purpose of screening is to identify people at risk of developing a specific disease. Screening tests must be valid, reliable and reproducible in the population in which screening is to take place, measurement techniques must be standardised and equipment must function properly [94, 95]. To be eligible for screening the condition should be a major health problem, it should be at a recognizably latent or an early symptomatic stage, and there should be a suitable diagnostic test that is available, safe and acceptable to the population concerned. There should be an agreed policy, based on test findings and national standards, as to a positive outcome of the screening procedure. There should also be an accepted and established treatment or intervention for individuals identified as having the disease or pre-disease condition, the facilities for treatment should be available and the cost of case-finding (including diagnosis and treatment) should be economically balanced in relation to possible expenditure on medical care as a whole [80]. By screening, subjects cannot be categorised as truly healthy or truly ill. Screening just indicates a need for further monitoring and work up in those who screen positive [80]. A follow-up period is necessary in order to differentiate between true and false positive test results [75].

Screening may be performed in different ways. One form is screening of the entire population, a kind of mass screening. An example is the mass screening for tuberculosis by X-ray performed in the 1950s. Another type is screening of subsets of the general population, usually based on age and sex, with a presumed increased risk of having the condition screened for [95]. The Study of Men Born in 1913 is an example of this type of screening [96].

Screening may have both benefits and disadvantages [97-99]. For instance, one problem when screening for high blood pressure or high blood glucose is that the blood pressure or blood glucose continuum must be converted into two discretionary entities, probably healthy or probably ill, using a cut-off level employed on the continuum. As a result four groups emerge: truly healthy, truly ill, false positive (labelled as ill but in fact healthy) and false negative (labelled healthy but in fact ill). Another problem is "labelling", which means that subjects screening positive, whether truly ill or false positive, develop behaviour like that of a sick person, which may result in low self-rated health [100]. How the information is transferred to an individual is strongly correlated to how the person interprets the content of the information [101]. The bottom-line issues are privacy and responsibility for the interpretation of screening results.

Screening for high blood pressure and high blood glucose has almost exclusively been performed by health care staff, although the screening locations vary. In the health care facilities, measuring blood pressures or blood glucose levels in patients coming for other reasons is a sort of non-

systematic screening. Since the 1970s screening at department stores, workplaces, and other places where people gather has increased.

In the 1990s, " opportunistic" screening became prevalent [102]. Opportunistic screening means that patients (or accompanying persons) coming for an appointment are screened for, *e.g.* blood pressure or blood glucose, regardless of the reason for the appointment. From an organisational point of view opportunistic screening is economically feasible, since the cost of screening is assumed to be marginal to that of the standard health care procedures for which the patient came. However, this hypothesis needs further testing.

The screening must be sufficiently long-term to cover a large enough proportion of the intended screening population. It has been shown that in settings where primary health care is the only health care provider, screening activities should last at least five years to cover 80% or more of the general population in the catchment area [103].

Like other forms of screening, opportunistic screening involves resource utilities, effectiveness, and costs in relation to the findings [104, 105]. For the individual, it is a matter of time allocation, potential for risk handling, psychological and social effects, while for society as a whole it involves the costs of carrying out the screening test and treatment, implications of false negative and false positive results as well as loss of production [95]. In this form of screening the time allocation problem, screening costs and loss of production may be modest and marginal to the costs for the appointment, which would have been generated in any case. However, there is little data concerning this issue. Furthermore, the revenues in the form of reduced costs for complications depend on assumptions that are difficult to calculate with any degree of confidence.

Cut-off value and receiver operating characteristic curve

Sensitivity, specificity, and positive predictive value are the most important factors in obtaining a reasonable precision in the screening procedure. Sensitivity is a measure of in how large a proportion of those with the condition being screened for that it is found. Specificity is a measure of the ability of the test to discriminate those with the condition from those who do not have it, or in other words the ability to identify those who do not have the condition. Positive predictive value measures the probability that a subject indicated by the test as having the condition screened for really has it.

As mentioned above, both blood pressure and blood glucose may be regarded as continuous measures. It is a problem to find the optimum cut-off level separating healthy subjects from those with hypertension or diabetes. The Receiver Operating Characteristic (ROC) [75] curve may be used to obtain that cut-off level. The ROC curve, where sensitivity is plotted against a reversed specificity scale, provides an optimum balance between sensitivi-

ty and specificity, and determines the cut-off level where this balance occurs. That level describes the best balance between false positives and false negatives. Unlike sensitivity and specificity, predictive value is highly influenced by the prevalence of the condition being screened for in the screening population. A highly sensitive and specific test will have a high predictive value in a population with a high prevalence of the condition screened for, and a lower or much lower, predictive value in a situation with low prevalence. In the present study, the hypertension prevalence may be assumed to be fairly high, perhaps more than 10%, while the diabetes prevalence may be assumed to be much lower, perhaps 3-4%. These circumstances may therefore be expected to affect the screening results, not only in terms of "screening yield", *i.e.*, the proportion screening positive, but also in terms of the proportion then given a diagnosis during work up.

The screening yield decreases for every repeated screening round in the same population. The first round may be seen as prevalence screening, the second as incidence screening, where those who developed the disease or risk factor between the first and second screening are found, as well as those who were misclassified as false negatives at the first screening occasion. This means that the positive predictive value will decrease after the first screening occasion [75]. Some researches also point out the need for research about the optimum time interval between screening periods [106].

Screening from a dental and a primary health care perspective

The majority of Swedish medical care is run by the counties, which have a similar legislative position as the US states. They are responsible for health care within their area, a municipality or part of a municipality, provided either by county council operated health care units (at the time of the study the vast majority) or by subcontracted private units. The general practitioner (GP) in primary health care is a specialist in family medicine. Nurses often have a specialist function, for instance as diabetes or hypertension nurses responsible for work ups and routine check-ups. Most of patients with chronic diseases such as diabetes or hypertension go to their local primary health care centre for regular check-ups.

Regarding dental health care the situation is similar, except that approximately half of the units are county council operated and the remaining are private units, subcontracted by the central government. However, all units, whether county council operated or private subcontractors, follow the same regulations.

Primary health care plays an important role in cardiovascular disease prevention. It has been proposed that large-scale cardiovascular disease screen-

ing and prevention programmes should be integrated into the regular primary health care system [107]. Various forms of high blood glucose screening have also been routinely performed. However, due to vacancies, a demanding routine health care burden, and lack of resources for tasks other than routine health care, screening activities have been limited.

Dental care, public and private, is the only health care sector that sees a large proportion of the population on a regular basis and might therefore be a suitable organisation for opportunistic screening. It is estimated that about 80% of the adults in Sweden visit a dentist for routine dental check-up in a two-year period [108]. At dental care clinic visits, the patients are routinely asked questions regarding their medical history that may affect treatment or prognosis or risks, such as intake of medication and tobacco use. This history taking is the most time consuming part of hypertension and high blood glucose screening.

A British study found that few dentists screened for high blood pressure, although more than 25% felt it was a good idea [109]. In a Swedish study, dentists used a computerised risk-score system to calculate the patient's risk of dying as a result of a cardiovascular disease event. Based on a pre-prepared guideline document, those with high scores were advised to seek medical advice regarding their condition [110]. Although a number of dental care clinics have performed high blood pressure or high blood glucose screening, few such screening events have been scientifically evaluated.

In this project, a somewhat different organisation was used as compared with previous projects. Co-operation was established between dental care and primary health care, where the dental care staff were supposed to perform the screening procedure, and primary health care was supposed to give support by providing screening equipment, calibrating the equipment, taking care of work ups of subjects screening positive, and handling treatment if a diagnosis was given.

During the planning phase of the study there were several issues that had to be handled. First, the feasibility of a screening and follow-up organisation like this one had never been tested before. Secondly, the willingness of dental care patients to participate in the screening procedure was unknown, as was thirdly, the effectiveness of the screening procedure. What are the numbers needed to screen (NNS) in an organisation like the present one, *i.e.*, how many subjects have to be tested to find one subject with diagnosis after work up? Fourthly, what are the costs of this type of screening and work up? A pilot study gave answers to some of these questions, after which the main project was launched.

Aims of the thesis

The aims of this thesis were to test the effects of a co-operation project between dental care and primary health care for screening and case-finding of subjects with hypertension and diabetes. The specific aims were:

- to analyse possible associations between dental health status in the form of deep periodontal pockets on the one hand and age, high blood pressure, and smoking habits on the other,
- to analyse the feasibility and effectiveness of screening for high blood pressure in dental care with follow up in primary health care in order to find subjects with hypertension in its early stages,
- to analyse the feasibility and effectiveness of screening for high blood glucose in dental care with follow-up in primary health care in order to find subjects with diabetes in its early stages,
- to analyse the costs of screening for high blood pressure and high blood glucose in dental care and follow-up in primary health care.

Study population and methods

Setting

The study described in Paper I was performed at a large dental care clinic in the city of Gävle (population 92,000), administrative centre of Gävleborg county (population 277,000), located 170 kilometres north of Stockholm, Sweden. The study described in Paper II was performed at two county council operated dental care clinics (Alfta and Edsbyn) located in the municipality of Ovanåker (population 12,000) in the northern part of Gävleborg County, approximately 250 kilometres north of Stockholm. The studies described in Papers III and IV were performed in the two Ovanåker clinics and one dental health care clinic in Strömsbro area in the city of Gävle. The three primary health care centres in the municipalities, all county council operated, were partners in the project and were responsible for calibration and quality control of the blood pressure and blood glucose meters and for the blood pressure and blood glucose follow-up in patients who screened positive.

Paper I

A total of 1,446 consecutive patients aged 35–65 years who came to the clinic for an annual dental check-up were invited to participate, and 1,239 (86%) agreed. The patients paid for the routine check-up, but all additional measurements needed for the study were taken free of charge.

A dental hygienist or a dental nurse performed a standardised interview about the subjects' general health, medication and tobacco use. The eight participating staff members were co-trained before the study. Tobacco use was classified as never used tobacco, tobacco ex-user, current smoker, or moist snuff user. Blood pressure was read (before the dental examination) in the sitting position, after 5 minutes' rest with a blood pressure watch (FUZZY-Logic, maximum recording error ±4 mmHg) around the left wrist held at heart level. If the diastolic blood pressure reading was above 90 mmHg, a second reading was done at the end of the visit, and the lowest value used in the analyses. No blood pressure reading was performed on subjects with previously known hypertension.

Fifty-four (4.4%) subjects had previously known and treated hypertension (case group 1), and 141 (11.4%) subjects had a blood pressure reading of

above 90 mmHg but no previously known high blood pressure (case group 2). For each case an age, sex and tobacco use matched referent was chosen from the group with diastolic blood pressure 90 mmHg or less, allowing an age mismatch of ± 6 years (because of the small group of snuff users among women). However, the inter-quartile range for the case-referent age difference was quite narrow, –1 to +2 years. The 195 cases and their 195 referents formed the study population for this report.

Dental status was determined on the basis of the traditional clinical examination, radiographic examination and periodontal pocket probe (HU-friedy) examination of all sides of the teeth, and recorded in the patient record. Pocket depth was measured from the margin of the gingiva to the bottom of the periodontal pocket, to the nearest millimetre. Based on patient record information, the number of deep dental pockets defined as periodontal pockets 5 millimetres or deeper (excluding the third molar) per subject was calculated. Number of erupted permanent teeth was counted. Subjects with a diastolic blood pressure of above 90mmHg were offered further assessment at the collaborating primary health care centre.

Paper II

At the two dental care clinics, all consecutive patients aged 20-65 scheduled for a regular check-up from 15 May 2003 to 20 December 2005 and living within the municipality were invited by letter to participate in the study. The screening procedure was performed at the dental care clinic appointment before the dental examination. Participants were asked to state their height and weight and whether they had a known hypertension. Those who did not know their weight had it measured on a lever balance scale, wearing indoor clothing, to the nearest tenth of a kilogramme. Those who did not know their height had it measured without shoes on a fixed wall measure to the nearest centimetre. Patients who had no known hypertension and who were in the age range 20-39 with a body mass index (BMI) higher than 25 kg/m^2 or in the age range 40-65 regardless of BMI were eligible for screening. Of the 1,791 eligible subjects 1,149 (64%) agreed to have their blood pressure measured. The agreement rate was highly age dependent as shown in Figure 1. The patients paid for the routine check-up, but all additional measurements due to the study were taken free of charge.

Blood pressure was measured in a sitting position, in the left upper arm, after 5 minutes' rest, with an automatic blood pressure reading device (Omron M4®). If the systolic blood pressure reading was above 160 mmHg or the diastolic blood pressure was above 90 mmHg a second reading was taken after the dental examination and the lowest recorded value was used as the screening blood pressure. Data measured at the dental care clinics were registered in pre-prepared protocols and entered into the study database. Sub-

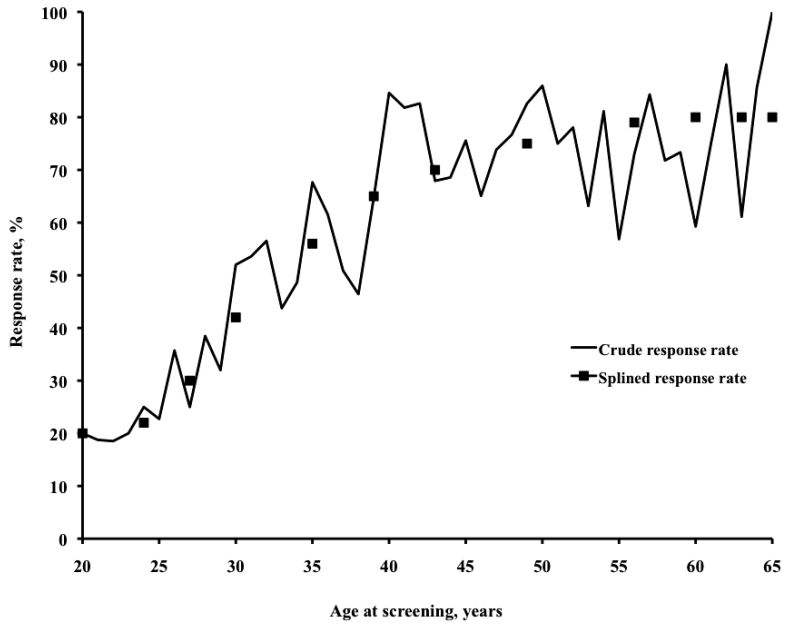

Figure 1 Screening participation rate by age.

jects with screening systolic blood pressure above 160 mmHg or diastolic blood pressure above 90 mmHg were asked for permission for being referred (all accepted). A copy of the dental service protocol was sent as the referral document for the work up to the subject's primary health care clinic, where an appointment was arranged.

Data on all appointments at the two primary health care clinics for the complete study population, regardless of screening result, for the three years preceding and the three years following the screening appointment were obtained from the primary health care medical records data base. To check for completeness, appointment logbooks were also scrutinised. Data included appointment date, category of care provider (GP, district nurse, hypertension nurse, physiotherapist, *etc.*), and for GP and hypertension nurse appointments, diagnoses. In addition, discharge diagnoses after hospital admissions within the three years following screening were scrutinised for hypertension. Mortality data for those who died (date of death and underlying diagnosis) were obtained from the National Cause of Death Register. PHC and hospital discharge diagnoses, and underlying causes of death were coded according to the International Classification of Diseases [111]. Moreover, the first primary health care clinic blood pressure readings for subjects referred from the dental care clinics to the primary health care clinics were obtained.

Three outcomes were used in this study. The first was whether the referred subjects actually came to the primary health care clinic for follow up, the second whether blood pressure was measured, and the third whether a

hypertension diagnosis was established during the first three years after screening. The presence of a hypertension diagnosis during the three years preceding screening was also sought for an additional check of hypertension status at the time of screening.

Paper III

All consecutive patients aged 20-65 scheduled for an annual examination at either of the two dental care clinics (Alfta and Edsbyn) in Ovanåker between 15 May, 2003 and 20 December, 2005 and living in the municipality, or aged 20-75 and scheduled for an annual check-up at the Strömsbro dental care clinic between 1 November, 2002 and 20 December, 2005 and living in the area, were invited by letter to participate in the study. In Ovanåker, 36% of the 1,791 subjects responding positively were excluded, in most cases because the BMI inclusion criterion was not met. The corresponding proportion in Strömsbro is not available, since data were lost.

The screening measurements were performed before the scheduled dental examination. Participants were asked for their height and weight and whether they had known diabetes. Those who did not know their weight had it measured on a lever balance scale, wearing indoor clothing, to the nearest tenth of a kilogramme. Those who did not know their height had it measured without shoes on a fixed wall measure to the nearest centimetre.

Subjects with no known diabetes and who were in the age range 20-39 with a BMI higher than 25 kg/m^2, or in the age range 40-65 regardless of BMI and living in Ovanåker, or in the age range 20-39 years with a BMI over 25 kg/m^2, or in the age range 40-75 years regardless of BMI and living in Strömsbro, were eligible for screening. In total, at the Alfta clinic 434, at the Edsby clinic 729, and at the Strömsbro clinic 405 subjects agreed to have their blood glucose measured, giving 1,568 subjects, constituting the study population of this report.

Samples for non-fasting blood glucose analysis were obtained as capillary blood from the patient's third fingertip, and analysed immediately with an Accu-chek Compact device (Roche Diagnostics Scandinavia AB, Sweden) in the Ovanåker dental care clinics, and with a Hemocue B-glucose analyser (Hemocue AB, Sweden) in the Strömsbro dental care clinic. The Accu-chek meter is used for self-monitoring and has a coefficient of variation of less than 3.1% at the 7.2 mmol/l glucose concentration level. The Hemocue meter is routinely used in health care units, and is suitable for use by staff with no laboratory experience. It has a coefficient of variation of 2.6%, at the 7.6 mmol/l glucose concentration level.

During the time of the project the glucose meters were re-calibrated from blood to plasma glucose analysis after a national consensus. Since the majority of values were measured as blood glucose, plasma glucose concentrations

were converted to blood glucose by dividing the plasma glucose values by a factor 1.11. Data measured at the dental care clinics were registered in pre-prepared protocols and entered into the study database. Subjects with a screening blood glucose level of 6.7 mmol/l or higher [95, 103, 112, 113] were asked for permission to be referred to their primary health care clinic (all accepted). A copy of the dental service protocol was sent as referral document to the subject's primary health care clinic, where an appointment was arranged.

Data from all appointments at the three primary health care clinics for the complete study population, regardless of screening result, during the three years preceding and the three years following the screening appointment were obtained from the primary health care medical record database. To check for completeness the appointment logbooks were also scrutinised. Data included date of appointment, category of care provider (*e.g.* GP, district nurse, hypertension nurse or physiotherapist), and the diagnosis given at the appointment with the GP and diabetes nurse.

Moreover, discharge diagnoses after hospital admissions within the three years preceding and following screening, obtained from the National Hospital Discharge register covering all hospital admissions in Sweden, were scrutinised for a diabetes diagnosis. Mortality data for those who died (date of death and underlying diagnosis) were obtained from the National Cause of Death Register. Primary health care centres, hospital discharge, and mortality diagnoses were coded according to the International Classification of Diseases [111] and were also given in plain text. Moreover, the first primary health care centre blood glucose reading for subjects referred from the dental care clinics to the primary health care centres were obtained.

The first outcome of this study was whether the referred patients actually came to the primary health care centre for follow-up, the second whether blood glucose was measured, and the third whether a diabetes diagnosis was established during the first three years after screening. The possibility of a diabetes diagnosis obtained during the three years preceding screening was also searched for in the records, to ascertain that persons with previously known diabetes were not including in the screening.

Paper IV

Paper IV is based on the screening study populations in the Alfta, Edsbyn, and Strömsbro dental care clinics, with follow-up in the corresponding primary health centres. However, for the purpose of this paper the study populations were subdivided into three groups, the 55 subjects who were screened for high blood pressure only, the 475 subjects screened for blood glucose only, and the 1,094 subjects screened for blood pressure as well as blood glucose. The total study population thus comprised 1,624 subjects.

Only direct costs were measured. The time per subject used for the screening procedure (screening time) was measured in minutes, and included history-taking regarding inclusion criteria (known hypertension or diabetes, age, height and weight), blood pressure or blood glucose measurements, and data registration, but not time for writing and sending invitation letters or other administrative procedures, and all this data was entered into the study database.

Information on wages, employer's fees, institutional overhead, accountable time, and measurements costs were obtained from Swedish Association of Local Authorities and Regions [114], and the central administration of the Gävleborg County Council. All Swedish employers pay an employer's fees to the central government, calculated as a percentage of the gross wages. The employer's fee is used to cover national health insurance contributions, pensions, *etc.* Institutional overheads are charged on all financial transactions in health care units to cover administrative costs. Accountable time is the fraction of working time that is used for work that is accountable, in this case direct health care activities, and is estimated to 65% of all working time. The remaining working time, used for administration, preparations for new work tasks, *etc.*, is the unaccountable time which, although it is not chargeable, has to be covered.

Ethics considerations

All participants gave their written informed consent concerning participation. The studies were performed in accordance with the Helsinki Declaration and were approved several times during the data collection process, first by the Research Ethics Committee at Uppsala University and later by the Regional Research Ethics Board.

Statistical Analysis

Data was analysed with the SAS statistical programme package version 6.12 (Paper I), version 9.1 (Paper II) and version 9.2 (Papers III and IV) [115]. Summary statistics, such as means, standard deviations and confidence intervals were computed with standard parametric methods. Differences between the groups in terms of continuous variables were tested with Student's t-test and categorical data with the chi-square test. P-values less than 5% were considered as indicating statistical significance.

Items specific to Paper I

The partial non-response rate (missing data in collected variables) was less than 4%. Odds ratios were computed with multivariate conditional logistic regression analysis, as were the regression surfaces shown in Figure 2.

Items specific to Paper II

The cumulative distribution of the first primary health care clinic post-screening follow-up appointments was analysed using Cox's proportional hazards regression, with the first appointment as outcome (dependent) variable and the group variable (screened positive or negative), age and sex as the independent variables. Follow-up time was computed as number of days from screening until outcome or end of follow- up. The subjects were censored at time of death or at end of follow-up, whichever came first.

The cumulative distribution of being given a hypertension diagnosis based on primary health care clinic and hospital records among subjects with no such diagnosis at screening was analysed accordingly, with first hypertension diagnosis as outcome and the group variable (screening positively or negatively), age, sex, and screening systolic and diastolic blood pressure as independent variables.

The numbers needed to screen (NNS) to identify a new case of hypertension, a parallel to numbers needed to treat (NNT) in randomised clinical drug trials, was computed in a similar way as NNT, as the reciprocal of the proportion of new cases found by screening, over and above those who would have been detected in any case [116]. The numbers used are shown in the Results section.

Items specific to Paper III

The cumulative distribution of first primary health care clinic post-screening follow-up appointment and of being given diabetes diagnosis was analysed using Cox's proportional hazards regression. In both analyses the time of first appointment and time of diagnosis, respectively, were used as outcome, and age, sex, BMI, blood glucose concentration at screening, and screening site (Alfta, Edsbyn, or Strömsbro) as determinants. The numbers needed to screen (NNS) to identify a person with unknown diabetes was computed in the same way as in Paper II.

Items specific to Paper IV

The following analysis models were used:
Dental care cost:

- number of screened subjects x screening time (adjusted for unaccountable time) x wages costs (adjusted for employer's fees) and overhead costs + analysis costs.

Primary health care costs:

- number of follow-up appointments x consultation time (adjusted for unaccountable time) x wages costs (adjusted for employer's fees) and overhead costs + analysis costs.

In dental care the total wages cost of screening was obtained by multiplying total time used by price per minute. Total analysis cost was obtained by multiplying number of screened subjects by analysis cost per screened subject, and total screening cost was obtained by adding total wages cost to total analysis cost. Cost per screened subject was obtained by dividing total screening cost by number of screened subjects. Cost per diagnosis in dental care was obtained by multiplying cost per screened subject by NNS.

In primary health care the standard follow-up schedule was three appointments with a nurse for blood pressure measurements and two appointments with a nurse for blood glucose measurements, in both cases followed by a single appointment with the GP for diagnosis assessment. The total time used for follow-up was then number of subjects times number of appointments per person, and for total wages costs total time used times price per minute. Total price per subject for follow-up was total wages costs for nurse and GP plus analysis costs divided by number of subjects followed up, and total price per diagnosis was obtained as total price divided by number of diagnoses.

NNS measures for blood pressure screening only were obtained from Paper II to arrive at stable and reasonably precise NNS measurements. NNS for blood glucoose screening only was obtained from Paper III for the same reasons. The group who had both blood pressure and blood glucose screening was large enough to allow for determination of a NNS specifically for that group.

Results

Paper I

Characteristics of the study population

Patient characteristics are shown in Table 1. Those with known hypertension and their referents were on average 54 years old, and those with previously unknown high blood pressure and their referents were 49 and 48 old years, respectively, a non-significant difference. Mean systolic and diastolic blood pressure were significantly higher in subjects with previously unknown high blood pressure than among their referents, but were fairly similar in the two reference groups.

Smoking habits were similar among cases and their referents with the exception that the proportion of previous tobacco users was lower among those with known hypertension than among their referents. Cases tended to have a smaller number of own teeth and a larger number of deep periodontal pockets than their referents, although these differences generally were small and insignificant. There was also a tendency towards a greater proportion of subjects with at least one deep periodontal pocket among the cases than among the referents, significant in the group with previously unknown high blood pressure.

Multivariate analyses

The results of multivariate logistic regression analyses in the two case-referent subgroups and in the total study population with being a case or referent as the dependent variable and presence of periodontal pocket 5 millimetres or deeper, age, sex, smoking habits, snuff taking and number of erupted teeth as independent variables is shown in Table 2. The findings were similar in the two sub-populations and the total study population. Subjects with periodontal pockets had 76% greater probability (adjusted odds ratio 1.76, 95%CI 1.14–2.72) of being a case than those who had no pockets.

Table 1. Patient characteristics. 95%CI=95% confidence interval, period.=periodontal. Previously unknown high diastolic blood pressure= high DBP

	High DBP		Referents			Known hypertension		Referents		
	Mean or %	95%CI	Mean or %	95% CI	p	Mean or %	95% CI	Mean or %	95% CI	p
No. of subjects	141		141			54		54		
Age, years	49.0	47.7-50.4	47.8	46.5-49.1	n.s.	54.1	52.3-55.8	54.1	52.4-55.8	n.s.
Females, %	51.8		51.8		n.s.	42.6		40.7		
Mean blood pressure										
Systolic, mmHg	156.5	153.5-159.6	125.2	122.9-127.5	<0.001	-	-	125.0	121.7-128.3	
Diastolic, mmHg	97.9	96.8-99.0	75.2	74.0-76.5	<0.001	-	-	74.7	72.9-76.5	
Tobacco use										
Current smokers, %	17.7		17.7		n.s.	7.4		7.4		n.s.
Moist snuff users, %	9.9		9.2.		n.s.	3.7		3.7		n.s.
Previous users, %	17.7		17.0		n.s.	7.4		31.5		<0.005
Dental data										
No. of teeth	26.5	25.8-27.2	27.2	26.6-27.8	n.s.	25.5	24.4-26.6	26.9	26.1-27.6	<0.05
No. of periodontal pockets ≥5 mm	3.5	2.6-4.4	2.6	1.6-3.5	n.s.	3.5	2.2-4.9	2.4	1.3-3.6	n.s.
Subjects with period. pockets ≥5 mm, %	57.1		42.6		<0.05	54.7		38.9		n.s.

Table 2. Odds ratios of having a hypertension diagnosis or a diastolic blood pressure reading >90 mmHg. Adjusted estimates were obtained in multivariate analysis. OR=adjusted odds ratio, 95% CI=95% confidence interval. Previously unknown high diastolic blood pressure= high DBP

	Known hypertension/ Referents		High DBP/ Referents		Total study population	
	OR	95%CI	OR	95%CI	OR	95%CI
Periodontal pocket ≥5 mm	2.00	0.83-4.86	1.74	1.03-2.93	1.76	1.14-2.72
Age	0.98	0.79-1.22	1.07	1.00-1.14	1.00	0.97-1.04
Sex	1.19	0.48-2.94	0.94	0.56-1.57	1.01	0.66-1.57
Smoke	0.97	0.16-5.87	0.73	0,36-1.49	0.90	0.47-1.73
Snuff	0.81	0.09-7.62	1.04	0.44-2.44	1.05	0.48-2.32
No. of teeth	0.82	0.69-0.96	0.96	0.90-1.02	0.94	0.88-1.00

Visualisation of the analysis model

The presence of deep periodontal pocket among cases and referents is in Figure 2 visualised in strata according to age and smoking habits. The difference in deep periodontal pocket prevalence between cases and referents persisted in all strata.

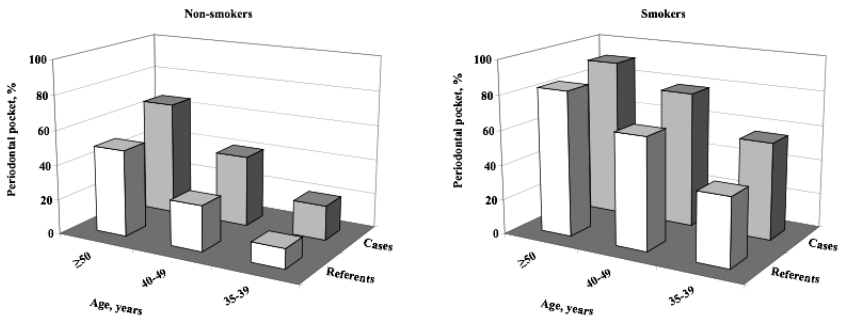

Figure 2. Proportion of periodontal pockets 5 millimetres or deeper in non-smoking and smoking cases (hypertension diagnosis or diastolic blood pressure reading higher than 90 mmHg) and referents in strata according to age

Paper II

Characteristics of the study population

Some characteristics of the study population are given in Table 3. Half the population was female, mean age at screening was 46 years, mean height 173 centimetres, mean weight 79 kilograms, and mean body mass index 26. During the three years preceding screening, 861 subjects, 74.9% of the 1,149 eligible subjects, had seen their GP at least once, on average 3.2 times per subject. Moreover, one (0.01%) subject had been admitted to hospital once. During the three years following screening 925 (80.5%) subjects saw their GP at least once, on average 3.9 times per subject, and six (0.5%) subjects had a total of 12 admissions to hospital. Seven (0.6%) subjects died during follow-up.

The distribution of the screening systolic and diastolic blood pressure is shown in Figure 3. The systolic blood pressure range was 84-223 mm Hg, mean 135 mmHg, median 133 mmHg. The corresponding values for diastolic blood pressure were 44-129 mmHg, 82 mmHg and 81 mmHg.

Out of the 1,149 subjects, 115 (10.1%) had screening systolic blood pressure above 160 mmHg, and 221 (19.2%) had screening diastolic blood pressure above 90 mmHg, Table 4. In all, 237 (20.6%) had systolic or diastolic blood pressure above the cut-off point, and were therefore referred to their primary health care centres. Of these subjects, 221 (93.2%) had no hypertension diagnosis in the primary health care centre records or hospital discharge data during the three years preceding the index dental service appointment, five (2.1%) had been subjected to a blood pressure work-up but no hypertension diagnosis was arrived at, and 11 (4.6%) had a previous hypertension diagnosis which they denied on the occasion of screening.

During the three years following screening 230 (97.1%) of the 237 subjects referred saw a district nurse or their GP, and had their blood pressure measured. The corresponding numbers among the non-referred was 695 (76.2%), p for difference <0.0001. Of the referred subjects, 84 (35.4%) were not given hypertension diagnoses, 77 (32.5%) were subjected to a hypertension work-up but were not given hypertension diagnoses, and 76 (32.1%) were given a hypertension diagnosis. The corresponding numbers for those not referred were 872 (95.6%), 14 (1.5%), and 26 (2.9%). The difference in work-up results between referred and non-referred subjects was highly significant ($p<0.0001$).

Of the 76 subjects who were given a hypertension diagnosis during follow up, 66 (86.8%) had no previous history of hypertension, two (2.6%) had a previous work-up performed but no diagnosis, and eight (10.5%) had a previous hypertension diagnosis.

Table 3. Characteristics of the study population

	N	Mean (SD) or %
No. of eligible patients	1,149	100
Mean age at screening, years	1,149	46.4 (9.52)
Women, %	573	49.9
Reported height, cm	1,149	172.7 (9.23)
Reported weight, kg	1,149	78.8 (14.78)
Body mass index, kg/m^2	1,149	26.3 (3.92)
Three-year period prior to screening		
GP appointments	3,639	
Patients seen by GP	861	74.9
Hospital admissions	1	
No. of patients admitted	1	0.1
Three-year period following screening		
GP appointments	4,309	
Patients seen by GP	925	80.5
Hospital admissions	12	
No. of patients admitted	6	0.5
Deceased after dental screening appointment	7	0.6

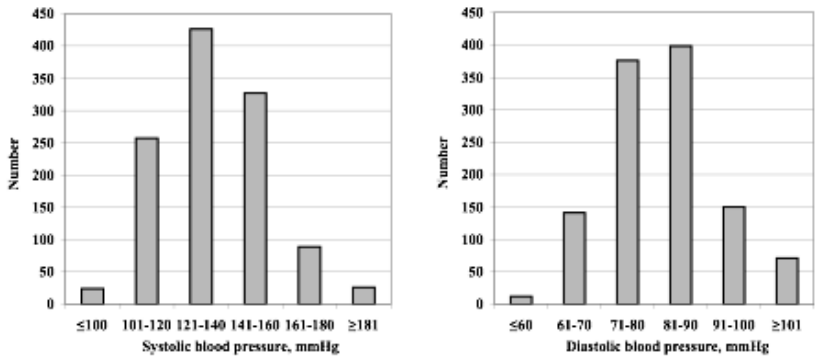

Figure 3. Distribution of screening systolic and diastolic blood pressure

In Figure 4A the cumulative distribution of first primary health care centre follow-up appointments by day after the screening is shown for those referred and those not referred. The cumulative proportion of subjects seeing their GP increased much more rapidly among referred subjects than among subjects not referred during the first 180 days. After this time period the rate

Table 4. Results of the screening procedure and follow up

	Screening result			
	Negative		Positive	
	n	%	n	%
Systolic blood pressure >160 mmHg	1,034	89.9	115	10.1
Diastolic blood pressure >90 mmHg	928	80.8	221	19.2
Systolic >160 mmHg or diastolic >90 mmHg	912	79.4	237	20.6
Hypertension history				
No previous hypertension diagnosis	892	97.8	221	93.2
Previous hypertension work-up but no diagnosis	5	0.5	5	2.1
Previous hypertension diagnosis	15	1.6	11	4.6
Subjects who saw their GP within 3 years	695	76.2	230	97.1
Blood pressure measured	-*)	-	230	97.1
No hypertension diagnosis	872	95.6	84	35.4
Hypertension work-up, no diagnosis	14	1.5	77	32.5
Hypertension diagnosis established	26	2.9	76	32.1

*) data not available

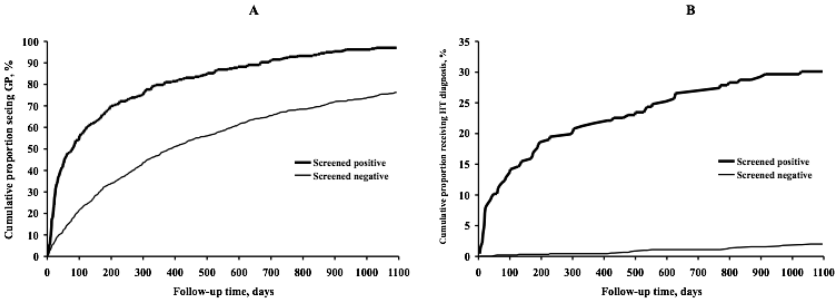

Figure 4. Cumulative percentage of those who screened positive and negative who saw their general practitioner during three years of follow up (A), and those who received a diagnosis of hypertension (B) during three years of follow up

of increase was about the same in the two groups, although the rate was at a higher level among referred. The tendency to see the GP was affected by referral (HR 2.55, 95%CI 2.18-2.98, p<0.0001), age (HR 1.02, 95%CI 1.01-1.02, p<0.0001), and sex (HR men to women 0.88, 95%CI 0.77-0.998, p<0.05).

The cumulative proportion of subjects who were given a hypertension diagnosis among those who had no diagnosis at screening is shown in Figure 4B. Among the referred subjects, the proportion with a hypertension diagno-

Table 5. Data for sensitivity, specificity, and predictive value calculations

	Work-up result		
	No hypertension diagnosis	Hypertension diagnosis	Total
Screening result			
Negative	879	18	897
Positive	158	68	226
Total	1,037	86	1,123

sis increased rapidly during the first few months after the dental appointment, then levelled off. Among the non-referred subjects the proportion increased slowly and successively during the three-year follow-up. The probability of being given a hypertension diagnosis was affected by age (HR 1.02, 95%CI 1.001-1.02) and systolic and diastolic screening blood pressure (HR 1.03, 95%CI 1.02-1.04, and 1.08, 95%CI 1.06-1.10, respectively), but not by sex (HR men to women 0.90, 95%CI 0.67-1.22).

Of those who were given a diagnosis, 59.2% were men, on average 51.9 (SD 6.94) years old, had a screening blood pressure of 169.9 (SD 18.03)/101.8 (SD 9.58) mmHg, and a first primary health care centre blood pressure reading of 154.1 (SD 19.89)/89.2 (SD 12.14) mmHg. The corresponding data for those who did not receive a diagnosis were 60.9%, 48.1 (SD 9.14) years, 156.1 (SD 13.54)/96.2 (SD 6.11) mmHg, and 136.6 (SD 12.57)/80.6 (SD 7.71) mmHg.

Of the 86 previously unknown cases of hypertension found during follow-up, 68 screened positive, yielding a sensitivity of 79.1%, Table 5. Of the 1,037 subjects who were not given a hypertension diagnosis during follow-up, 879 screened negative, giving a specificity of 84.8%. Of the 226 with no previous hypertension diagnosis and who screened positive, 68 were given a hypertension diagnosis, yielding a positive predictive value of 30.1%. A Receiver Operating Characteristics curve (ROC) analysis showed that the optimal systolic blood pressure screening level would have been 145-150 mmHg and the diastolic level 85-90 mmHg.

Among subjects who screened negative, 18 out of 897 (2.0%) were given a hypertension diagnosis during follow-up, Table 5. Assuming the same detection rate among all the subjects screened would have given approximately 23 (2% of 1,149 subjects) subjects with new hypertension diagnoses if no screening had been performed. With screening, 63 (86-23) new hypertensive patients were identified, over and above those who would have been detected in any case. NNS based on these assumptions would then be 1/(63/1,149) = 18.2 screened to find one case.

Paper III

Characteristics of the study population

Approximately half of the study population was screened at the Edsbyn clinic, and one fourth each at the Alfta and Strömsbro clinics, Table 6. Half of the subjects were female, mean age at screening was 49 years, mean height 173 centimetres, mean weight 79 kilograms, mean BMI 26.5 kg/m^2, and mean blood glucose concentration 5.4 mmol/l. The blood glucose distribution groups ranged from ≤4.6 to ≥10.7 mmol/l.

Table 6. Characteristics of the study population

	N	Mean (SD) or %
No. of screened patients by clinic		
Ovanåker/Alfta clinic	434	27.7
Ovanåker/Edsbyn clinic	729	46.5
Strömsbro clinic	405	25.8
Mean age at screening, years	1,568	48.6 (10.20)
Women, %	776	49.5
Reported height, cm	1,532	172.7 (9.26)
Reported weight, kg	1,532	79.5 (14.84)
Body mass index, kg/m^2	1,541	26.5 (3.95)
Blood glucose level at screening, mmol/l	1,568	5.38 (1.04)
≤ 4.6 mmol/l	384	24.5
4.7-6.6 mmol/l	1,029	65.5
6.7-8.6 mmol/l	139	8.9
8.7-10.6 mmol/l	12	0.8
≥ 10.7 mmol/l	4	0.3
Three-year period prior to screening		
GP appointments	5,375	
Patients seen by GP	1,186	75.6
Hospital admissions	10	
No. of patients admitted	7	0.4
Three-year period following screening		
GP appointments	6,152	
Patients seen by GP	1,267	80.8
Hospital admissions	20	
No. of patients admitted	16	1.0
Deceased	14	0.9

During the three years preceding screening 5,375 appointments were made by 1,186 subjects (75.6% of the 1,568 who were screened), on average 4.5 appointments each with the GP. Moreover, 7 (0.4%) subjects had been admitted to hospital, on average 1.4 times. During the three years following screening 6,152 appointments were made by 1,267 (80.8%) subjects, on average 4.9 appointments per subject, 16 (1.0%) were admitted to hospital, on average 1.3 times. Fourteen (0.9%) subjects died during follow-up.

Screening outcome

Of the 1,568 subjects screened, 155 (9.9%) had a screening blood glucose of 6.7 mmol/l or higher and were referred to their primary health care centres, Table 7. None had a diabetes diagnosis in the primary health care records or hospital discharge data during the three years preceding the screening appointment.

Table 7. Proportion who screened positive or negative, diabetes history, and results of work-up in primary health care

	Screening results			
	Negative		Positive	
	n	%	n	%
Blood glucose level ≥ 6,7 mmol /l	1,413	90.1	155	9.9
Previous diabetes diagnosis or glucose examination	0	0	0	0
Follow-up after referral				
Subjects seeing GP within 3 years	1,137	80.5	139	89.7
Blood glucose measured	-*)	-	135	87.1
No diabetes diagnosis	1,405	99.4	146	94.2
Diabetes work-up, no diagnosis	7	0.5	7	4.5
Diabetes diagnosis established	8	0.6	9	5.8

*) data not available

During the three years following screening 139 (89.7%) of the 155 referred subjects saw their GP and 135 (87.1%) had their blood glucose measured, 9 (5.8%) were diagnosed with diabetes mellitus, whereas 7 (4.5%) were checked for diabetes with negative results. Among non-referred subjects 1,137 subjects saw their GP, 8 (0.6%) were diagnosed with diabetes and 7 (0.5%) were checked for diabetes with a negative result.

The cumulative distribution of the first primary health care centre follow-up appointment is shown in Figure 5A. The difference between referred and non-referred subjects in proportion seeing a GP increased somewhat during the first follow-up year, after which it was stable. The probability of a first follow-up appointment was significantly influenced by

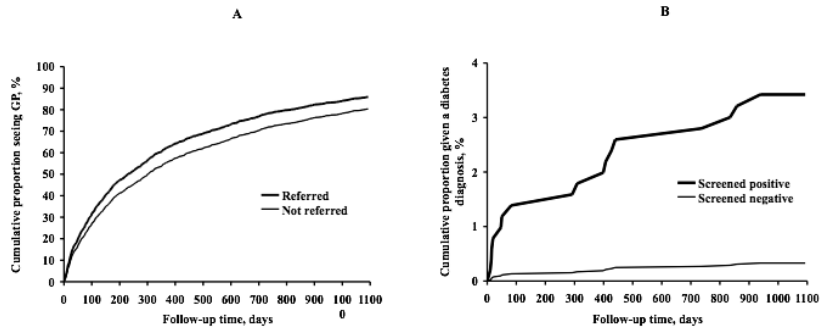

Figure 5. Cumulative proportion of first appointments with a general practitioner during three years of follow-up after screening for diabetes in dental health care among subjects screening positive or negative (A) and cumulative proportion diagnosed with diabetes during three years of follow up after screening for diabetes in dental health care among subjects screening positive or negative (B)

age (HR 1.02, 95%CI 1.02-1.03, p<0.0001), BMI (HR 1.03, 95%CI 1.02-1.04, p<0.0001), and sex (HR 0.81 for men versus women, 95%CI 0.71-0.93, p<0.0005). However, screening at different dental care clinics, and screening for blood glucose concentration had no significant influence.

The cumulative proportion of subjects diagnosed with diabetes is shown in Figure 5B. Among the referred subjects, the proportion diagnosed with diabetes increased initially, then levelled off, and then increased again. Among the non-referred subjects there was a slow but steady increase on a low level over time. The probability of being diagnosed with diabetes was influenced by screening blood glucose concentration (HR 2.25, 95%CI 1.89-2,67 p<0.0001), BMI (HR 1.12, 95% CI 1.03- 1.19, p<0.05), and age (HR 1.04, 95%CI 1.00-1.08, p<0.05). Neither sex nor at which dental care clinic the screening was performed had any significant influence.

The screening sensitivity was 52.9% (9 out of 17 new cases correctly identified), specificity 90.6% (1,405 of 1,551 non-diabetes subjects correctly identified), and positive predictive value 5.8% (9 diabetes cases among the 155 subjects screening positive). A receiver operating characteristics curve (ROC) analysis showed that the optimum blood glucose screening cut-off level would have been 5.7 mmol/l.

Numbers needed to screen

Among subjects who screened negative, 8 out of 1,413 (0.57%) were diagnosed with diabetes during follow-up, Table 8. Assuming the same detection rate in the whole study population, approximately 9 subjects (0.57% x 1,568) would have been diagnosed with diabetes if no screening had been performed. With screening, over and above the normal detection rate, 17 subjects in the total study population were diagnosed with diabetes. Thus, 8

Table 8. Numbers with diagnosis of diabetes, screened positive, and screened by age and body mass index

	Body mass index group					
	No data	15-19	20-24	25-29	30+	Total
Age group						
20-29	0/0/0	0/0/0	0/0/0	0/2/46	0/5/21	0/0/7/67
30-39	0/0/0	0/0/0	0/0/0	0/7/122	1/7/69	0/1/14/191
40-49	0/0/10	0/0/11	2/0/15/269	1/1/25/224	1/0/6/62	4/1/46/576
50-59	0/1/8	0/0/8	0/23/221	2/26/214	1/3/13/73	1/5/63/524
60-69	0/0/6	0/0/2	0/5/63	1/0/9/85	1/1/7/26	2/1/21/182
70+	0/0/3	0/0/2	0/0/10	1/4/10	1/0/0/3	1/1/4/28
Total	0/0/1/27	0/0/0/23	2/0/43/563	2/4/73/701	4/5/38/254	8/9/155/1,568

Numbers in boxes: The far right =number participating in the screening,
The second from the right=number screening positive and referred for work-up,
The third from the right number=number referred diagnosed with diabetes,
The fourth from the right number=number non-referred diagnosed with diabetes

(17-9) subjects with a new diabetes diagnosis were found thanks of screening. NNS based on these assumptions would then be 1/(8/1,568) = 196 screened to find one new case of diabetes.

Alternative screening criteria

The size of the screening population, numbers screening positive, numbers of incident cases with diabetes found at screening, and number of incident diabetes cases not found at screening, by age and BMI, are shown in Table 8. It is obvious that the incident diabetes cases found at screening were found in a limited subset of the study population (framed area in Table 8). Those who screened positive were found in the combination of age 30 years or older and BMI 20 kg/m^2 or higher. Subjects diagnosed with diabetes were found in the combination age 30 years or older and BMI 30 kg/m^2 or higher, or age 40 years or older and BMI 25 kg/m^2 or higher. If only the part of the study population where the incident diabetes cases were found had been screened, the screening population would have been 766 subjects, those screening positive 97, number of incident cases found 9, number of incident cases among those screening negative 6, sensitivity 60.0%, specificity 88.3%, and positive predictive value 9.3%. NNS based on these assumptions would have been 1/8/766 = 96.

Based on the optimum screening blood glucose level 5.7 mmol/l or higher used in the total screening population, 485 would have screened positive, 13 incident diabetes cases would have been found, 4 among 1,083 subjects would have screened negative, sensitivity would have been 76.5%, specificity 69.6%, positive predictive value 2.7%, and NNS 1/11/1568=143.

Combining a narrower screening population size according to Table 8 and a cut-off point at 5.7 mmol/l or higher would have yielded 766 subjects screened, 12 out of 15 incident cases would have been found, sensitivity would have been 80.0%, specificity 65.5%, positive predictive value 4.4%, and NNS would have been 1/10/766 = 77.

Paper IV

Characteristics of the study population

Among the 55 subjects screened for high blood pressure only, two thirds were women, mean age was 36 years, and 5 (9.1%) screened positive, Table 9. Among the 475 subjects screened for high blood glucose only, half were women, mean age was 52 years, and 47 (9.9%) screened positive. Among the 1,094 subjects screened for both high blood pressure and high blood glucose, slightly fewer than half were women, mean age was 47 years, and 313 (28.6%) screened positive.

The time used for screening was 7.8 minutes in the groups screened for high blood pressure or for high blood glucose, and 8.8 minutes in the groups screened for both blood pressure and blood glucose. After adjustment for unaccountable time, the time used for screening was 12.0, 12.0 and 13.5 minutes, respectively.

In primary health care, three follow-up appointments was used as the standard in the work-up for high blood pressure and two in the work-up for high blood glucose. The crude time used per appointment was 20 minutes in those followed up for high blood pressure only, 10 minutes for high blood glucose only, and 20 minutes for the combined blood pressure-glucose group. After adjustment for unaccountable time the corresponding numbers were 30.8, 15.4, and 30.8 minutes.

Cost related characteristics

In dental care, dental hygienists performed the screening. The crude price per screening minute was 2.60 SEK, Table 10. In primary health care nurses or district nurses performed the work-up, and a GP made the final decision on whether or not the subject had either a hypertension or a diabetes diagnosis. The crude cost per minute for a nurse was 2.60 SEK, and for s GP 6.01 SEK. The employer's fee was 43% for all three staff types, and the overhead cost was 36% in primary health care and 50% in dental care. The total cost per minute was 5.06 SEK in dental care, 5.06 SEK for nurses and 11.69 SEK for GPs. There were no specific costs other than staff costs for blood pressure measurements. The cost per blood glucose analysis was 5.75 SEK at all units.

Table 9. Characteristics of the screening population

	Blood pressure screening only		Blood glucose screening only		Blood pressure and glucose screening	
	N	Mean (SD) or %	N	Mean (SD) or %	N	Mean (SD) or %
N	55		475		1,094	
Women, %	37	67.3	241	50.7	536	49.0
Age, years						
Mean		35.7 (5.94)		52.4 (11.0)		46.9 (9.35)
Median		36		53		47
Inter-quartile range		32-39		44-60		41-54
Dental care						
Blood pressure screening results						
Positive	5	9.1			232	21.2
Negative	50	90.9			862	78.8
Blood glucose screening results						
Positive			47	9.9	109	10.0
Negative			428	90.1	985	90.0
Screening time	21		146		526	
Accountable time, minutes		7.8 (1.78)		7.8 (2.54)		8.8 (2.31)
Median		8.0		8.0		9.0
Inter-quartile range		7-10		5-10		7-10
Mean screening time adjusted for unaccountable time, minutes		12.0		12.0		13.5
Primary health care						
Follow-up appointments per positively screened subject		3		2		2-3
Consultation time, minutes						
Accountable time		20.0		10.0		20.0
Adjusted for unaccountable time		30.8		15.4		30.8

Table 10. Financial characteristics. All costs are given in SEK

	Dental care	Primary health care	
	Dental hygienist	Nurse	GP
Cost per minute,	2.60	2.60	6.01
Employer's fees %	43	43	43
Overhead costs %	50	36	36
Total minute cost,	5.58	5.06	11.69
Cost per blood glucose analysis,	5.75	5.75	-

Screening costs

The screening costs are presented in Table 11. In each of the three screening groups the total time used for screening was obtained by multiplying the numbers screened by adjusted screening time. The total wages cost for screening was obtained by multiplying total time used by cost per minute. Total analysis cost was obtained by multiplying number of screened subjects by analysis cost per screened subject, and total screening cost was obtained by summing total wages cost with total analysis cost. Cost per screened subject was obtained by dividing total screening cost by number of screened subjects.

The same NNS levels as found in previous studies for blood pressure and blood glucose screening were used for blood pressure screening only (NNS=18) and for blood glucose screening only (NNS=196). For the combined blood pressure and blood glucose screening a new NNS was computed. Among the 1,094 subjects, 80 new diagnoses were found in the 313 who screened positive for blood pressure or blood glucose, and 22 (2.82%) among the 781 who screened negative, altogether 102 diagnoses. If no screening had been performed the incidence of new diagnoses would have been similar to that among those screening negative, and 2.82% x 1,094= 31 new diagnoses would have been found. This means that 102-31=71 new diagnoses were found thanks to screening, yielding an NNS=1/71/1,094=15.

Cost per diagnosis in dental care, obtained by multiplying cost per screened subject by NNS, was 1,206 SEK for blood pressure screening only, 14,308 SEK for blood glucose screening only, and 1,215 SEK for combined blood pressure and glucose screening. The total cost of screening and follow-up per diagnosis found was 5,298 SEK for blood pressure screening only, 19,100 SEK for blood glucose screening only, and 4,116 SEK for the combined screening.

Table 11. Costs for blood pressure screening only, blood glucose screening only, and screening for both conditions

	Blood pressure screening only	Blood glucose screening only	Blood pressure and glucose screening
Dental care			
Numbers screened	55	475	1,094
Adjusted screening time	12	12	13.5
Total time used, minutes	660	5,700	14,769
Price per minute	5.58	5.58	5.58
Total wages cost	3,683	31,806	82,411
Analysis costs per screened subject	0	5.75	5.75
Total analysis cost	0	2,731	6,291
Total screening cost	3,683	34,537	88,702
Cost per screened subject	67	73	81
Numbers needed to screen (NNS)	18	196	15
Cost per diagnosis	1,206	14,308	1,215
Primary health care			
No. attending PHC for follow-up	5	37	232+109, 313[§]
No. of follow-up appointments			
Nurse	5x3	37x2	232x3+81x2
GP	5x1	37x1	313x1
Adjusted consultation time,			
Nurse	30.8	15.4	30.8/15.4
GP	30.0	30.0	30.0
Total time used nurse, minutes	462.0	1,140	23,932
Total time used GP, minutes	150.0	1,110	9,390
Costs per minute			
Nurse	5.06	5.06	5.06
GP	11.69	11.69	11.69
Total wages costs			
Nurse	2,338	5,768	121,096
GP	1,754	12,976	109,769
Analysis cost	0	426	1,254
Number of diagnoses	1	4	75+5
Total costs per subject for work-up	818	518	742
Total cost per diagnosis	4,092	4,792	2,901
Total cost per diagnosis	5,298	19,100	4,116

[§] 204 subjects referred for high blood pressure only, 81 subjects referred for high blood glucose only, and 28 subjects referred for both high blood pressure and blood glucose, 313 subjects referred for either high blood pressure or high blood glucose

General discussion

Summary of findings

In Paper I, high blood pressure was significantly associated with the prevalence of 5 millimetres or deeper periodontal pockets after adjustments for the effects of age, sex, tobacco use and number of teeth. In Paper II, the first of the papers on the co-operation between dental and primary health care services, every fifth patient who came for a regular dental examination and opportunistic blood pressure screening had systolic blood pressure higher than 160 mmHg or diastolic blood pressure higher than 90 mmHg. Of those who screened positive, almost all saw their GP for a blood pressure follow-up, and one third were given a hypertension diagnosis within three years after screening. Screening sensitivity was 79%, specificity 85%, positive predictive value 30%, and NNS 18.

In Paper III, every tenth of the subjects screened positive for high blood glucose, of whom 90% saw their GPs, 87% had their blood glucose checked, and 6% were diagnosed with diabetes. The screening sensitivity was 53%, specificity 91%, and positive predictive value 6%. Limiting the screening population to individuals at higher risk of diabetes or lowering the cut-off level improved these measurements. There were no significant differences in results between the three screening dental care services.

In Paper IV, including screening for both high blood pressure and high blood glucose, the cost per case for high blood pressure screening in dental care was 67 SEK, for high blood glucose screening 73 SEK and for the combined screening 81 SEK. The corresponding cost for follow up in primary health care was 818 SEK, 518 SEK, and 742 SEK, respectively. The corresponding cost per diagnosis arrived at were 5,298 SEK, 19,100 SEK, and 4,116 SEK.

Validity

The project described in Paper I was conducted as an addendum to the normal routine in a public dental care clinic, a form of opportunistic screening where the patient was offered the service when he or she attended the dental care clinic for the annual dental check-up. More than 60% of the adult population in Gävleborg County sees a dentist in the Public Dental Service at

least annually [117]. The study population in this project is therefore fairly representative of the underlying age segment of the general population.

Altogether, 15.8% of the subjects in Paper I had previously known hypertension or a diastolic blood pressure reading above 90 mmHg. The prevalence of hypertension demanding treatment in the general population has been estimated to 10–15% [118]. Since the classification of high diastolic blood pressure was based on one reading only in the majority of cases, the true hypertension prevalence in the study population appears to be approximately the same as in the general population.

All staff members involved in the project described in Paper I were co-trained for data collection. The blood pressure maximum recording error of ± 4 mmHg is much less than average observer variation in manual readings [118]. The well-known problem of "white coat hypertension" [119-122], *i.e.,* artificially high blood pressure readings owing to subjects` tension in the measurement situation, affects blood pressure readings in all situations, with the possible exception of home blood pressure readings [123, 124], and is therefore not a problem specific to this study.

The automatic blood pressure measurements reduced the possibility of dependent misclassification in the blood pressure – periodontal pocket relationship. The fact that the blood pressure classification was based on only one or two readings rather than a clinical work-up for subjects with high readings lessens the precision, *i.e.*, causes a non-differential misclassification bias in this classification. The effect is therefore most likely a dilution of the true relationship between periodontal pockets and their determinants rather than the creation of a false relationship.

Another possible source of bias is the number of remaining erupted teeth, since the potential number of deep pockets depends on the number of teeth. In addition, loss of teeth may also be linked to prevalent deep pockets. To get around this problem, the number of remaining erupted teeth was taken into account in all analyses. We therefore have no reason to believe that the data are biased to such an extent that the conclusions would be affected.

The conditions during the blood pressure screening performed in Paper II were basically the same as in blood pressure screening performed by medical care practitioners. The blood pressure measurement procedure was standardised, with all measurements in the left arm after at least five minutes' rest. It has previously been shown that the blood pressure level falls during the first few minutes of rest but has attained a stable level within five minutes, irrespective of individual blood pressure level [125, 126]. The Omron M4® device has been tested against manual blood pressure readings. The variability of the readings appears to be comparable to that for manual readings performed by different observers [127]. The equipment was regularly checked by the co-operating primary health care centres in accordance with guidelines [128].

Cut-off levels

In spite of the tendency to have higher readings at screening than during work-up, the screening blood pressure level indicating hypertension as proposed by the Fourth Joint European Societies Recommendation on Prevention of Coronary Heart Disease in Clinical Practice guidelines [76] was used. In Paper II, 70% of subjects who screened positive were false positives in the sense that they were not later given a hypertension diagnosis during the three-year follow-up. Using a higher cut-off blood pressure level would have yielded fewer false positives and higher specificity but lower sensitivity. In this study a cut-off level that turned out to be close to the optimum was chosen, as determined using the ROC curve based analysis.

The cut-off point of non-fasting blood glucose 6.7 mmol/l or higher (corresponding to 120 mg/dl or higher) used in Paper III was the recommended level used in previous primary care diabetes screening studies [95, 98, 112]. Given the recommended fasting blood glucose level in repeated tests above 6.0 mmol/l, the screening non-fasting blood glucose cut-off level used in Paper III seems reasonable. However, a lower cut-off level, such as 5.7 mmol/l or higher, might have been more effective in this population. A cut-off level of 5.6 mmol/l or higher (corresponding to 100 mg/dl or higher) has previously been suggested as the most effective level, associated with the lowest cost per detected case in screening for undiagnosed diabetes and prediabetes [129].

Periodontitis

Periodontitis is a chronic disease with multi-factorial aetiology, which usually has a slow development and few symptoms. Periodontitis and gingivitis share the same aetiological factors, and represent different clinical manifestations of the same fundamental disease process. It is unclear why and in what cases gingivitis progresses to periodontitis. The differences could be attributable to the response of the host to the microbial challenge [130]. It is important to know that deep periodontal pockets that remain inflamed after local treatment may be attributable, to some extent, to poor general health. Periodontitis is, for example, more common among subjects with diabetes and there is a statistically significant difference in clinical tooth attachment loss between diabetes patients with poor metabolic control, patients with satisfactory metabolic control, and healthy referents [69, 131, 132].

A positive relationship between high blood pressure and risk of cardiovascular disease has been recognised for a long time. Whether periodontal disease is a risk factor for systemic disease and whether dental infection is a risk factor for coronary heart disease remains to be determined [47, 133, 134]. The same applies to whether or not the association between deep peri-

odontal pockets and blood pressure is a causal relationship. Studies on mechanisms involved in periodontal disease show associations with various stressors: a relationship between negative events and psychological factors on the one hand and periodontal disease on the other [135]. It appears that psychological and oral risk factors taken together may result in periodontal disease [136, 137].

Hypertension and diabetes

The risks associated with high blood pressure in terms of developing various forms of cardiovascular disease are well known and have been summarised in the Fourth Joint European Societies Recommendation on Prevention of Coronary Heart Disease in Clinical Practice guidelines [76]. The general idea of the guidelines is that, all things considered, early detection and treatment of high blood pressure is associated with a better outcome than if the condition is detected late in its course.

Receiving early treatment in hypertension or diabetes may reduce complication rate. The Diabetes Cost Effectiveness Study group assumed that the opportunistic screening would reduce the pre-diagnosis interval with on average 5 years [138]. It has been shown that targeting diabetes screening to people with hypertension is even more cost effective, and also that screening subjects in the age range 55-75 years influenced the cost effectiveness positively [139], findings in line with those in this study.

A strong correlation between blood pressure, diabetes and obesity has been shown [17]. In this study, for those of younger ages, a cut-off value for body mass index was used as a criterion for participation. As shown in Paper III, BMI is an important criterion for identifying subjects who will screen positive for high blood glucose. Studies have also shown that a high waist circumference measurement is a supplementary predictor of cardiovascular events [140, 141]. Waist measuring can easily be performed at the dental care clinic as compared with measuring height and weight and calculating BMI.

Screening and follow-up

Traditionally, blood pressure screening, especially in connection with scientific studies, has been performed by special organisations, *i.e.,* separately and not in conjunction with a regular clinic appointment. However, the participation rate is a moderate 60%-67% and the costs of screening are high [41]. The alternative, opportunistic screening, means using an existing organisation, where screening costs are expected to be marginal in relation to the total cost of the organisation. Opportunistic screening with subsequent medi-

cal care should preferably be performed by primary health care. However, the screening must be long-term, with each screening round taking up to five years to screen 80% or more of the general population [103]. In the present study the mean participation rate was 64%, while in the age group of most interest in blood pressure screening, 40 years of age or older, the participation rate was 70%-80% during the three-year screening period, as shown in Figure 1.

Screening carried out at other types of facilities, such as supermarkets [142-144] and pharmacies [145-149] have been reported as successful in terms of the number of people screened (numerator), but may imply problems, such as handling of confidential information, and the uncertainty of the size and geographical delineation of the underlying general population (denominator). By screening at the dental care services, as in the present study, a number of these problems were avoided. There are no problems with handling of confidential information, and the underlying general population can easily be determined. In all screening activities, subjects who screen positive must be followed up. In this study, the follow-up was carried out by primary health care, the cooperating partner. This partnership was one of the prerequisites for success.

Although the study was performed in Sweden, the results appear to be applicable to all geographical areas with a similar structure of medical and dental services, for instance the other Nordic countries and the United Kingdom.

Numbers needed to screen

The effectiveness of screening in terms of NNS largely depends on the characteristics of the underlying screening population, such as age distribution, disease prevalence, proportion of non-diagnosed cases, as well as on the characteristics of the screening procedure, e.g. type of screening, response rate among those invited to participate and cut-off levels at screening. This may be illustrated by results from this and other studies. In the total screening population in Paper III, 196 individuals had to be screened to find one diabetes case. Restricting the screening population and modifying the cut-off level brought the NNS down to 77. In a nationwide population screening programme in Brazil, the NNS was 64 [150], and in a project performed among high-risk patients in the US the NNS was 40 [151].

The NNS found for blood glucose screening stands in sharp contrast against the NNS of 18 found in blood pressure screening in the Ovanåker subset of the present study population [152]. There may be several reasons for this discrepancy. First, the probability of finding previously unknown cases (positive predictive value) depends on the prevalence of the disease. The prevalence of hypertension is at least three times higher than that of

diabetes. Secondly, those screening positive for high blood pressure came to the primary health care centres for follow-up to a somewhat higher extent than those screening positive for high blood glucose (97% versus 89%). The reason for this discrepancy is not clear. Blood glucose measurements at follow-up involving invasive procedures may have been seen as more discouraging than a non-invasive blood pressure measurement. The attitude to high blood pressure with a widely known increased risk of stroke or myocardial infarction may have been different from reactions to an asymptomatic elevation of blood glucose, for which the awareness of the severity of the long-term consequences may have been less. Moreover, a diabetes diagnosis is often known to require lifestyle changes, including diet and increased physical activity, to a larger extent than a hypertension diagnosis, and may consequently have a stronger impact on life both inside and outside the family.

Alternative approaches to delimitate the screening population

Using risk criteria such as age and BMI for inclusion in the screening process decreased the number of subjects screened for high blood glucose without too much sensitivity loss. Such a model, with criteria delineating a high risk group, is congruent with recent recommendations from the Swedish National Board of Health and Welfare [77].

More elaborate methods have been suggested, such as questionnaires focussing on heredity and other risk factors. Studies have shown that certain combinations of criteria would be suitable for high blood glucose screening [153]. American studies have shown that self-reported family history on diabetes, hypertension, high cholesterol level and clinical evidence of periodontal disease together carry a probability of 27- 53% of having undiagnosed diabetes [153]. Using periodontal disease as a criterion increased the possibility of finding a diabetes case [67, 154].

A similar approach is represented by the “Findrisk” questionnaire [155, 156]. By means of a simple questionnaire the indications for a blood glucose test may be found. Findrisk contains eight questions on age, family history, physical activity, diet, waist circumference, body mass index, prescription of antihypertensive medication and whether or not blood glucose had been elevated in earlier screenings or check-ups [157]. This questionnaire may be a useful tool for delineating the diabetes screening population in dental care, in spite the fact that it introduces a complication in the form of a need for more time in the screening process.

Costs for screening and follow up

The time spent on screening in the dental care clinics is in line with other studies and estimations [158]. The cost for screening per subject in the dental care clinics was moderate. Most of the expense was associated with follow-up in primary health care, because more than one appointment was needed and each appointment took longer than the screening occasion, especially for blood pressure follow-up.

The screening time at the dental care clinics was to a large extent taken up by history-taking and information about the screening, as well as to create a calm atmosphere. The time needed for the actual blood pressure and blood glucose measurements was much shorter. This is the main reason why combined screening only took less than two minutes more than screening for either high blood pressure or high blood glucose.

The cost of finding undiagnosed subjects with diabetes varies by study population, the purpose of screening and the cut-off value. A study performed in the US about efficient cut-off points among subjects in the age range 45- 74 years, showed that in the year 2000 the most efficient cut-off point was about 6.7 mmol/l, giving a cost that ranged from $392-671 per case found. If patients' travelling time and time for taking the test were included, the cost ranged from $504-990 [129]. The same proposed cut-off value was used in the present study.

Paper III showed that narrowing the inclusion criteria improved the NNS from 196 to 96, which might decrease the dental care screening cost per case found by about 50% and total cost, including follow-up cost, from approximately 19,000 to 12,000 SEK. The screening population could be made even narrower by means of questionnaires [157]. Using presence of periodontitis as an additional criterion might be considered [29, 67, 154]. However, all these predictive factors making the diabetes screening more efficient also mean making the selection of screening population more complicated. However, a model with narrower inclusion criteria in blood glucose screening than used in this study is in line with recent recommendations from the Swedish National Board of Health and Welfare [77].

Strengths and limitations

The strengths of this study include the fact that the study was performed as opportunistic screening in dental care, the only medical service that sees a considerable proportion of the general public annually or biannually, yielding a large study population at low cost. The blood pressure and blood glucose measurement equipment were standard equipment used at health care units treating hypertension and diabetes patients, or for self-monitoring of patients with hypertension and diabetes. The accuracy of both types of

equipment may therefore be regarded as sufficient for screening purposes [159]. The co-operation with primary health care was a prerequisite for a successful work-up of subjects screening positive. Other strengths include the close monitoring of outcome: the information on hypertension or diabetes diagnoses during follow-up was almost 100% complete.

The limitations include scanty clinical information from the GP appointments, such as the hypertension or diabetes diagnosis criteria. However, we have reasons to believe that the GPs were following the national guidelines for diagnosing hypertension and diabetes, based on World Health Organization (WHO) recommendations, or that they used somewhat higher diagnostic blood pressure or blood glucose levels [160]. This means that the results of this study are minimum results in the sense that diagnostic procedures carried out strictly according to guidelines might have yielded even better results.

One weakness in the cost calculations is that there was information only on the first appointment with primary care during follow-up. The total number of follow-up appointments therefore had to be estimated based on guidelines for diagnosis assessment and on local rules. Another was that the time needed for the GP's diagnosis assessment was estimated by the participating GPs and from the literature [139].

The individuals in the study population were instructed not to smoke or drink coffee for 30 minutes before screening, since smoking may increase blood pressure during a short period following intake [161]. Epidemiological studies have produced contradictory findings regarding the association between blood pressure and coffee consumption. Some studies with repeated administration of caffeine have shown a persistent presser effect, whereas in other studies chronic caffeine ingestion was not found to increase blood pressure [162, 163].

The extent to which the screening population is representative of the underlying general population in this study is uncertain. The screening populations in Alfta and Edsbyn are most probably representative, since the dental care clinics were the dominant dental care providers. The situation in Strömsbro may be different, since it is part of the city of Gävle with a large number of alternative dental care providers. Subjects who participated in the screening project may differ from the corresponding segment of the general population, for instance regarding educational level [164, 165], since the project was performed in a time window, inviting subjects who were coming for a dental check-up during that time window. If this project were made permanent, the situation might be different, since approximately 80% of the underlying population would be invited to participate.

Implications

The results of this study indicate new possibilities for improving public health. Since the dental service, public or private, sees a large proportion of this population on a regular basis it might be a useful venue for opportunistic screening [166-170]. In the discussions on the involvement of dental care in a screening process, it is important to take a number of aspects into consideration, such as the involvement and engagement of dental care in health behaviour thinking, and the collaboration between dental and primary health care in relation to the patient. The best way for the dental care clinics to be involved in screening projects, such as screening for high blood pressure and high blood glucose, is by cooperation with other health care organisations. What role dental care can play in this public health field therefore depends on how other public health programmes are organised. It is also important to be attentive to the staff situation in primary health care. Shortages of district nurses and GPs may have an influence on the possibility of being active in opportunistic screening and collaboration projects.

Another important factor is the local community support. In the Västerbotten project, where the municipality became an active part, the intervention was planned to address every individual in a certain age span about lifestyle factors [84]. It is interesting that the collaborative-screening programme in Ovanåker influenced the local municipality to produce leaflets about healthy lifestyle choices, where representatives from the local primary health care and dental care clinics wrote the text. The Ovanåker project also received positive attention in the media.

Conclusions

- The prevalence of periodontal pockets 5 millimetres or deeper was associated with prevalent established hypertension or a high blood pressure reading after adjustment for the influence of age, sex, tobacco use and number of teeth. Whether the relationship between blood pressure and periodontitis is a causal one remains to be explored. Screening for high blood pressure at regular appointments at the dental care clinic may give the dental care system an important new role in the field of public health.
- In the co-operative project between dental and primary health care, the blood pressure screening procedure was efficient. One fifth screened positive, the vast majority of those who screened positive came for follow-up, and one third of those who screened positive were given a hypertension diagnosis during the three-year follow-up. On average, for every 18 subjects screened one case of hypertension was found. The procedure therefore appears to be an effective way of detecting unknown hypertension.
- Screening for elevated blood glucose was successful in terms of response rate and attendance at follow-up. Since the diabetes prevalence is moderate (approximately 3.5%) the outcome in terms of numbers needed to screen to find one case of diabetes was found to be in the range 77-196 depending on delineation of the screening population and the blood glucose cut-off concentration.
- Owing to the fact that hypertension is more prevalent than diabetes, the number needed to screen was rather low for high blood pressure screening as compared to this number in high blood glucose screening. No assessments of reduced costs owing to early detection and thereby reduced hospital admissions for complications were made, but the screening and follow-up costs appear to be modest. Combining high blood pressure screening and high blood glucose screening could reduce costs for establishing a diagnosis even further, since more diagnoses may be arrived at.

Summary in Swedish (svensk sammanfattning)

Det hälsofrämjande och preventiva arbetet betonas alltmer och skall genomsyra hela hälso- och sjukvården samt vara en självklar del i all vård och behandling. En utgångspunkt i det preventiva tänkandet är att ju tidigare en sjukdom upptäcks, desto bättre blir prognosen. Ett sätt för tidig upptäckt är att via olika former av screening finna tecken på eller förstadier till sjukdom hos enskilda individer i en till synes frisk population. En typ av screening är opportunistisk screening, då man utnyttjar en befintlig vård- eller annan verksamhet, som förutom sina ordinarie uppgifter även får screeningsuppgiften. En sådan potentiell screening-verksamhet kan vara tandvården som redan i dagsläget regelbundet ser en mycket stor del av befolkningen och genomför en form av regelbunden screening efter munhålesjukdomarna karies och tandlossning. Samverkan mellan dessa orala sjukdomar och livsstilsjukdomar är välkända och studier har även visat på en association mellan kärlproblematik och oral hälsa.

Vi beslutade därför att pröva opportunistisk screeningverksamhet inom tre tandvårdskliniker i Gävleborgs län, Alfta, Edsbyn och Strömsbro i Gävle, i samarbete med primärvården på samma orter. I Delarbete I testade vi ett sedan tidigare ”välkänt” men sparsamt belagt samband mellan ålder, blodtryck och rökning å ena sidan och förekomst av tandköttsfickor å den andra. Dessutom testades möjligheten att göra storskalig blodtrycksmätning inom tandvården. I Delarbete II redovisade vi effekten av screening för högt blodtryck, i Delarbete III effekten av screening för högt blodsocker, och i Delarbete IV redovisas ekonomiska aspekter på screeningen.

Delarbete I

Engström S, Gahnberg L, Högberg, Svärdsudd K. Association between high blood pressure and deep periodontal pockets. Ups J Med Sci 2007;112: 95-103.

På en tandvårdsklinik i Gävle utfördes blodtrycksmätning i samband med vanlig tandvårdundersökning. Syftet med delarbetet var att studera om det fanns något samband mellan uppmätt blodtryck och tandstatus på patienter i en vanlig tandvårdsklinik. I studien ingick 1 239 patienter i åldern 35 -65 år. Samtliga förutom de som hade ett redan känt högt blodtryck fick sitt blod-

tryck mätt. Blodtrycket mättes med en blodtrycksmanschett avsedd för handleden. Ett diastoliskt blodtryck på mer än 90 mmHg definierades som högt.

Totalt 54 individer hade ett redan känt högt blodtryck och 141 hade vid blodtrycksmätningen ett högt diastoliskt blodtryck. Till dessa individer matchades fram kontroller med diastoliskt blodtryck på högst 90 mmHg. Multivariat analys visade att signifikant fler individer i gruppen med högt diastoliskt blodtryck hade fördjupade tandköttsfickor (mer eller lika med 5 mm), även efter justering för ålder, kön, tobaksvanor och antalet kvarvarande tänder. Resultatet visar på att det finns en association mellan blodtryck och fördjupade tandköttsfickor och att blodtrycket därmed berör den orala tandhälsan. Projektet visar att det är möjlighet att mäta blodtryck i tandvården, studien var inte designad för att kunna beräkna sensitivitet, specificitet och positivt prediktivt värde.

Delarbete II

Engström S, Berne C, Gahnberg L, Svärdsudd K. Efficacy of screening for high blood pressure in dental health care. BMC Public Health 2011, 11:194 http://www.biomedcentral.com/1471-2458/11/194

Blodtrycksscreening har tidigare huvudsakligen bedrivits som systematisk screening inom speciellt upprättade enheter eller som osystematisk opportunistisk screening av patienter som av annat skäl kommit till en vårdenhet, oftast i primärvården. Tandvården är speciellt lämpad för systematisk opportunistisk screening eftersom en stor del av befolkningen regelbundet kommer för kontroll utan att ha några besvär. Den aktuella studien genomfördes som ett samarbetsprojekt mellan tandvården och primärvården i Ovanåkers kommun i Hälsingland, där tandvårdens roll var att screena för högt blodtryck och primärvårdens att hjälpa till med utrustning, kalibrering och uppföljning av de som screenade positivt.

I samband med kallelse till tandvårdsbesök inbjöds patienter att kostnadsfritt få blodtrycket mätt. 1149 personer 20-65 år gamla och utan tidigare blodtrycksdiagnos deltog i studien. Blodtrycket mättes i tandläkarstolen med en automatisk blodtrycksmätare (Omron 4®) före tandvårdsundersökningen. Tvåhundratrettiosju personer med systoliskt blodtryck över 160 mmHg eller diastoliskt blodtryck över 90 mmHg remitterades till primärvården för uppföljning. Hela screeningspopulationen följdes under 3 års tid efter screeningstillfället. Utfallsdata var huruvida de remitterade kom till uppföljning på vårdcentralen och när de kom, om blodtrycket följdes upp och om hypertonidiagnos sattes. Dessa uppgifter erhölls via granskning av journaler i primärvård, via data från slutenvård och från dödsorsaksregistret. Av de remitterade gick 230 (97%) till hälsocentralen inom 3 år, de flesta inom ett halvår. Nästan alla fick blodtrycket mätt och 76 (32%) fick hypertonidiagnos. Scre-

eningens sensitivitet var 79%, specificitet 85% och positivt prediktivt värde 30%. Numbers needed to screen, en pendang till numbers needed to treat i randomiserade behandlingsstudier, var 18, det vill säga blodtrycket behövde i genomsnitt mätas hos 18 personer för att hitta en person med tidigare okänt högt blodtryck, vilket får bedömas som ett lågt tal. Screeningsmodellen var således synnerligen effektiv. En förutsättning för den höga effektiviteten var den samverkan mellan parterna som etablerades innan screeningsförsöket påbörjades.

Delarbete III

Engström S, Berne C, Gahnberg L, Svärdsudd K. Effectiveness of screening for diabetes mellitus in dental health care. Inskickad för ställningstagande till publicering.

Blodsockerscreening i tandvården utfördes med samma organisatoriska uppbyggnad som är beskrivet avseende blodtrycksscreening i delarbete 2. Även denna aktuella studie genomfördes som ett samarbetsprojekt mellan tandvården och primärvården i Ovanåkers kommun i Hälsingland samt även i Strömsbro, Gävle. Tandvårdens roll var att screena för högt blodsocker och primärvårdens att hjälpa till med utrustning, kalibrering och uppföljning av de som screenade positivt.

I samband med kallelse till tandvårdsbesök inbjöds patienter till att kostnadsfritt få blodsockret mätt. 1568 personer, 20-65 år gamla i Ovanåker samt 20 -75 år i Strömsbro, utan tidigare diabetesdiagnos tackade ja. Blodsockret mättes i tandläkarstolen, på traditionellt sätt med ett stick i fingret och blodglukosvärdet mättes med en av två blodglukosmätare, Accu-chek Compact device® (Roche Diagnostics Scandinavia AB, Sweden) eller Hemocue B-glucose analyzer® (Hemocue AB, Sweden). Provtagningen utfördes före tandvårdsundersökningen. Etthundrafemtiofem (9.9%) personer med blodsocker på 6,7 mmol/l eller mer remitterades till primärvården för uppföljning. Hela screeningspopulationen följdes under 3 års tid efter screeningstillfället. Utfallsdata var huruvida de remitterade kom till uppföljning på vårdcentralen och när de kom, om blodsockret följdes upp, och om diabetesdiagnos sattes. Dessa uppgifter erhölls via granskning av journaler i primärvård och slutenvård samt från dödsorsaksregistret.

Av de remitterade gick 139 (89,7%) till hälsocentralen inom 3 år, de kom något tidigare än den grupp som screenades negativt, dock inte med någon signifikant skillnad. 135 (87,1%) fick blodsockret mätt och 9 (5.8%) fick diabetesdiagnos. Screeningens sensitivitet var 53%, specificitet 91% och positivt prediktivt värde 6%. Numbers needed to screen (NNS) var 196, d.v.s. för att hitta en ny diabetiker behövde 196 personer screenas. Studien visade även att det är möjligt att effektivisera blodsockerscreeningen genom att använda snävare inklusionskriterier beträffande BMI och ålder. Den sam-

verkan mellan parterna som etablerades innan screeningsförsöket påbörjades var en förutsättning för projektets genomförande.

Delarbete IV

Engström S, Berne C, Borgquist L, Gahnberg L, Svärdsudd K. Health economic evaluation of screening for hypertension and diabetes in dental care and follow up in primary health care. Manuskript.
Syftet med delarbete 4 var att beräkna de direkta kostnaderna vid screening utifrån resultaten i delarbete 2 och 3. På grundval av hur screeningpopulationen valde att delta i blodtrycks-screening och blodsocker-screening bildades tre grupper, de som enbart deltog i blodtrycks-screening, en som deltog enbart i blodsocker-screening och en tredje grupp som deltog i båda. Med utgångspunkt i NNS-talen för blodtrycks-screeningen i delarbete 2 (NNS=18) och motsvarande för blodsockerscreeningen i delarbete 3 (NNS=196) visades att blodtrycks-screeningen var betydligt mindre kostnadskrävande per funnen diagnos än blodsocker-screening. Kombinerad blodtrycks-screening och blodsocker-screening, d.v.s. då båda screeningarna utfördes vid samma tillfälle gav det fördelaktigaste utfallet (NNS=15), ett extremt lågt och fördelaktigt värde. Totala kostnaden för screeningen och uppföljningen för att finna ett positivt fall, d.v.s. endera hypertonidiagnos eller diabetesdiagnos, blev omkring 5 300 SKr om enbart blodtrycksscreening utfördes, cirka 19 000 Skr för att finna ett fall om enbart blodsockerscreening utfördes samt omkring 4 000 Skr om både blodtrycksscreening och blodtrycksscreening utfördes vid samma tillfälle.

Betydelse

Avhandlingens betydelse ligger dels i analysen av genomförbarhet och kostnadseffektivitet av att använda en existerande vårdverksamhet som tandvården för screening av högt blodtryck och högt blodsocker. Avhandlingen visar att screeningen var effektiv och att en samverkan mellan parterna var framgångsrik. Ur ett folkhälsoperspektiv kan det finnas anledning att överväga om tandvårdens folkhälsoinriktade verksamhet kan utvecklas till att förutom arbetet med tobak och kostfaktorer, även innefatta screening och case-finding av andra viktiga ohälsofaktorer i samarbete med primärvården.

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References

1. Agardh E, Moradi T, Allebeck P: [The contribution of risk factors to the burden of disease in Sweden. A comparison between Swedish and WHO data]. *Lakartidningen* 2008, 105:816-821.
2. Hooker RC, Cowap N, Newson R, Freeman GK: Better by half: hypertension in the elderly and the 'rule of halves': a primary care audit of the clinical computer record as a springboard to improving care. *Fam Pract* 1999, 16:123-128.
3. Weinehall L, Ohgren B, Persson M, Stegmayr B, Boman K, Hallmans G, Lindholm LH: High remaining risk in poorly treated hypertension: the 'rule of halves' still exists. *J Hypertens* 2002, 20:2081-2088.
4. Cranney M, Barton S, Walley T: The management of hypertension in the elderly by general practitioners in Merseyside: the rule of halves revisited. *Br J Gen Pract* 1998, 48:1146-1150.
5. Scheltens T, Bots ML, Numans ME, Grobbee DE, Hoes AW: Awareness, treatment and control of hypertension: the 'rule of halves' in an era of risk-based treatment of hypertension. *J Hum Hypertens* 2007, 21:99-106.
6. U.S. Department of Health and Human Services; National Institutes of Health; National Heart LaBI, National High Blood Pressure Education Program: The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and tretment of High Blood Pressure(JNC 7). In *Book The seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and tretment of High Blood Pressure(JNC 7)* (Editor ed.^eds.). City; 2004.
7. Parati G, Stergiou GS, Asmar R, Bilo G, de Leeuw P, Imai Y, Kario K, Lurbe E, Manolis A, Mengden T, et al: European Society of Hypertension guidelines for blood pressure monitoring at home: a summary report of the Second International Consensus Conference on Home Blood Pressure Monitoring. *J Hypertens* 2008, 26:1505-1526.
8. Rosengren A, Eriksson H, Larsson B, Svardsudd K, Tibblin G, Welin L, Wilhelmsen L: Secular changes in cardiovascular risk factors over 30 years in Swedish men aged 50: the study of men born in 1913, 1923, 1933 and 1943. *J Intern Med* 2000, 247:111-118.
9. Ribacke M, Tibblin G, Rosengren A, Eriksson H: Is hypertension changing? Blood pressure development in cohorts of 50-year-old men between 1963 and 1993. *Blood Press* 1996, 5:134-138.
10. Psaltopoulou T, Naska A, Orfanos P, Trichopoulos D, Mountokalakis T, Trichopoulou A: Olive oil, the Mediterranean diet, and arterial blood pressure: the Greek European Prospective Investigation into Cancer and Nutrition (EPIC) study. *Am J Clin Nutr* 2004, 80:1012-1018.

11. Nissinen A, Pietinen P, Tuomilehto J, Vartiainen E, Iacono JM, Puska P: Predictors of blood pressure change in a series of controlled dietary intervention studies. *J Hum Hypertens* 1987, 1:167-173.
12. Rosen M, Alfredsson L, Hammar N, Kahan T, Spetz CL, Ysberg AS: Attack rate, mortality and case fatality for acute myocardial infarction in Sweden during 1987-95. Results from the national AMI register in Sweden. *J Intern Med* 2000, 248:159-164.
13. Gulliksson M, Wedel H, Koster M, Svardsudd K: Hazard function and secular trends in the risk of recurrent acute myocardial infarction: 30 years of follow-up of more than 775,000 incidents. *Circ Cardiovasc Qual Outcomes* 2009, 2:178-185.
14. Vartiainen E, Puska P, Pekkanen J, Tuomilehto J, Jousilahti P: Changes in risk factors explain changes in mortality from ischaemic heart disease in Finland. *Bmj* 1994, 309:23-27.
15. O'Flaherty M, Allender S, Taylor R, Stevenson C, Peeters A, Capewell S: The decline in coronary heart disease mortality is slowing in young adults (Australia 1976-2006): A time trend analysis. *Int J Cardiol* 2011.
16. Dobson AJ, Gibberd RW, Wheeler DJ, Leeder SR: Age-specific trends in mortality from ischemic heart disease and cerebrovascular disease in Australia. *Am J Epidemiol* 1981, 113:404-412.
17. SBU: Moderately Elevated Blood Pressure *The Swedish Council of Technology Assesment in Health Care* 2004.
18. Wild S, Roglic G, Green A, Sicree R, King H: Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004, 27:1047-1053.
19. Jonsson B: Revealing the cost of Type II diabetes in Europe. *Diabetologia* 2002, 45:S5-12.
20. Jansson SP, Andersson DK, Svardsudd K: Prevalence and incidence rate of diabetes mellitus in a Swedish community during 30 years of follow-up. *Diabetologia* 2007, 50:703-710.
21. Andersson DK, Svardsudd K, Tibblin G: Prevalence and incidence of diabetes in a Swedish community 1972-1987. *Diabet Med* 1991, 8:428-434.
22. UK Prospective Diabetes Study 6. Complications in newly diagnosed type 2 diabetic patients and their association with different clinical and biochemical risk factors. *Diabetes Res* 1990, 13:1-11.
23. Brohall G, Behre CJ, Hulthe J, Wikstrand J, Fagerberg B: Prevalence of diabetes and impaired glucose tolerance in 64-year-old Swedish women: experiences of using repeated oral glucose tolerance tests. *Diabetes Care* 2006, 29:363-367.
24. Ringborg A, Lindgren P, Martinell M, Yin DD, Schon S, Stalhammar J: Prevalence and incidence of Type 2 diabetes and its complications 1996-2003--estimates from a Swedish population-based study. *Diabet Med* 2008, 25:1178-1186.
25. Agardh CD, Berne C, Östman J. Diabetes. *ISBN91-47-04899-9* Stockholm Liber AB, 2002.
26. Harris MI, Klein R, Welborn TA, Knuiman MW: Onset of NIDDM occurs at least 4-7 yr before clinical diagnosis. *Diabetes Care* 1992, 15:815-819.

27. Cheung BM: The hypertension-diabetes continuum. *J Cardiovasc Pharmacol* 2010, 55:333-339.
28. Berglund G, Larsson B, Andersson O, Larsson O, Svardsudd K, Bjorntorp P, Wilhelmsen L: Body composition and glucose metabolism in hypertensive middle-aged males. *Acta Med Scand* 1976, 200:163-169.
29. Thorstensson H, Kuylenstierna J, Hugoson A: Medical status and complications in relation to periodontal disease experience in insulin-dependent diabetics. *J Clin Periodontol* 1996, 23:194-202.
30. Ceriello A: Hypothesis: the "metabolic memory", the new challenge of diabetes. *Diabetes Res Clin Pract* 2009, 86 Suppl 1:S2-6.
31. Clarke P, Gray A, Adler A, Stevens R, Raikou M, Cull C, Stratton I, Holman R: Cost-effectiveness analysis of intensive blood-glucose control with metformin in overweight patients with type II diabetes (UKPDS No. 51). *Diabetologia* 2001, 44:298-304.
32. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, Nathan DM: Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 2002, 346:393-403.
33. Alberti KG, Zimmet P, Shaw J: International Diabetes Federation: a consensus on Type 2 diabetes prevention. *Diabet Med* 2007, 24:451-463.
34. Williams R, Van Gaal L, Lucioni C: Assessing the impact of complications on the costs of Type II diabetes. *Diabetologia* 2002, 45:S13-17.
35. Herman WH: The economics of diabetes prevention. *Med Clin North Am* 2011, 95:373-384, viii.
36. Norris SL, Kansagara D, Bougatsos C, Fu R: Screening adults for type 2 diabetes: a review of the evidence for the U.S. Preventive Services Task Force. *Ann Intern Med* 2008, 148:855-868.
37. Griffin SJ, Borch-Johnsen K, Davies MJ, Khunti K, Rutten GE, Sandbaek A, Sharp SJ, Simmons RK, van den Donk M, Wareham NJ, Lauritzen T: Effect of early intensive multifactorial therapy on 5-year cardiovascular outcomes in individuals with type 2 diabetes detected by screening (ADDITION-Europe): a cluster-randomised trial. *Lancet* 2011, 378:156-167.
38. Kruijshoop M, Feskens EJ, Blaak EE, de Bruin TW: Validation of capillary glucose measurements to detect glucose intolerance or type 2 diabetes mellitus in the general population. *Clin Chim Acta* 2004, 341:33-40.
39. Rohlfing CL, Little RR, Wiedmeyer HM, England JD, Madsen R, Harris MI, Flegal KM, Eberhardt MS, Goldstein DE: Use of GHb (HbA1c) in screening for undiagnosed diabetes in the U.S. population. *Diabetes Care* 2000, 23:187-191.
40. Khader YS, Al-Zu'bi BN, Judeh A, Rayyan M: Screening for type 2 diabetes mellitus using gingival crevicular blood. *Int J Dent Hyg* 2006, 4:179-182.
41. Welin L, Adlerberth A, Caidahl K, Eriksson H, Hansson PO, Johansson S, Rosengren A, Svardsudd K, Welin C, Wilhelmsen L: Prevalence of cardiovascular risk factors and the metabolic syndrome in middle-aged men and women in Gothenburg, Sweden. *BMC Public Health* 2008, 8:403.
42. Mooney J, Hodge PJ, Kinane DF: Humoral immune response in early-onset periodontitis: influence of smoking. *J Periodontal Res* 2001, 36:227-232.

43. Reibel J: Tobacco and oral diseases. Update on the evidence, with recommendations. *Med Princ Pract* 2003, 12 Suppl 1:22-32.
44. Li Q, Chalmers J, Czernichow S, Neal B, Taylor BA, Zoungas S, Poulter N, Woodward M, Patel A, de Galan B, Batty GD: Oral disease and subsequent cardiovascular disease in people with type 2 diabetes: a prospective cohort study based on the Action in Diabetes and Vascular Disease: Preterax and Diamicron Modified-Release Controlled Evaluation (ADVANCE) trial. *Diabetologia* 2010.
45. Holmlund A, Holm G, Lind L: Severity of periodontal disease and number of remaining teeth are related to the prevalence of myocardial infarction and hypertension in a study based on 4,254 subjects. *J Periodontol* 2006, 77:1173-1178.
46. Bergstrom J, Eliasson S, Dock J: A 10-year prospective study of tobacco smoking and periodontal health. *J Periodontol* 2000, 71:1338-1347.
47. Friedewald VE, Kornman KS, Beck JD, Genco R, Goldfine A, Libby P, Offenbacher S, Ridker PM, Van Dyke TE, Roberts WC: The American Journal of Cardiology and Journal of Periodontology Editors' Consensus: periodontitis and atherosclerotic cardiovascular disease. *Am J Cardiol* 2009, 104:59-68.
48. Genco R, Offenbacher S, Beck J: Periodontal disease and cardiovascular disease: epidemiology and possible mechanisms. *J Am Dent Assoc* 2002, 133 Suppl:14S-22S.
49. Molgaard CA, Bartok A, Peddecord KM, Rothrock J: The association between cerebrovascular disease and smoking: a case-control study. *Neuroepidemiology* 1986, 5:88-94.
50. Buhlin K, Gustafsson A, Hakansson J, Klinge B: Oral health and cardiovascular disease in Sweden. *J Clin Periodontol* 2002, 29:254-259.
51. Gustafsson A, Asman B, Bergstrom K: Cigarette smoking as an aggravating factor in inflammatory tissue-destructive diseases. Increase in tumor necrosis Factor-alpha priming of peripheral neutrophils measured as generation of oxygen radicals. *Int J Clin Lab Res* 2000, 30:187-190.
52. Taguchi A, Sanada M, Suei Y, Ohtsuka M, Lee K, Tanimoto K, Tsuda M, Ohama K, Yoshizumi M, Higashi Y: Tooth loss is associated with an increased risk of hypertension in postmenopausal women. *Hypertension* 2004, 43:1297-1300.
53. Mattila KJ, Valtonen VV, Nieminen M, Huttunen JK: Dental infection and the risk of new coronary events: prospective study of patients with documented coronary artery disease. *Clin Infect Dis* 1995, 20:588-592.
54. Danesh J, Whincup P, Walker M, Lennon L, Thomson A, Appleby P, Gallimore JR, Pepys MB: Low grade inflammation and coronary heart disease: prospective study and updated meta-analyses. *BMJ* 2000, 321:199-204.
55. Mattila KJ: Dental infections as a risk factor for acute myocardial infarction. *Eur Heart J* 1993, 14 Suppl K:51-53.
56. Beck JD, Offenbacher S, Williams R, Gibbs P, Garcia R: Periodontitis: a risk factor for coronary heart disease? *Ann Periodontol* 1998, 3:127-141.
57. DeStefano F, Anda RF, Kahn HS, Williamson DF, Russell CM: Dental disease and risk of coronary heart disease and mortality. *Bmj* 1993, 306:688-691.

58. Kornman KS, Page RC, Tonetti MS: The host response to the microbial challenge in periodontitis: assembling the players. *Periodontol 2000* 1997, 14:33-53.
59. SBU. *Chronic Periodontitis-Prevention, Diagnosis and treatment. A Systematic Review*. Stockholm. The Swedish Council on Technology Asses-ment in Health Care 2002.
60. Savage A, Eaton KA, Moles DR, Needleman I: A systematic review of definitions of periodontitis and methods that have been used to identify this disease. *J Clin Periodontol* 2009, 36:458-467.
61. Sahingur SE, Sharma A, Genco RJ, De Nardin E: Association of increased levels of fibrinogen and the -455G/A fibrinogen gene polymorphism with chronic periodontitis. *J Periodontol* 2003, 74:329-337.
62. Loos BG, Craandijk J, Hoek FJ, Wertheim-van Dillen PM, van der Velden U: Elevation of systemic markers related to cardiovascular diseases in the peripheral blood of periodontitis patients. *J Periodontol* 2000, 71:1528-1534.
63. Grossi SG: Treatment of periodontal disease and control of diabetes: an assessment of the evidence and need for future research. *Ann Periodontol* 2001, 6:138-145.
64. Firatli E: The relationship between clinical periodontal status and insulin-dependent diabetes mellitus. Results after 5 years. *J Periodontol* 1997, 68:136-140.
65. Ship JA: Diabetes and oral health: an overview. *J Am Dent Assoc* 2003, 134 Spec No:4S-10S.
66. Grossi SG, Zambon JJ, Ho AW, Koch G, Dunford RG, Machtei EE, Norderyd OM, Genco RJ: Assessment of risk for periodontal disease. I. Risk indicators for attachment loss. *J Periodontol* 1994, 65:260-267.
67. Demmer RT, Jacobs DR, Jr., Desvarieux M: Periodontal disease and incident type 2 diabetes: results from the First National Health and Nutrition Examination Survey and its epidemiologic follow-up study. *Diabetes Care* 2008, 31:1373-1379.
68. Nesbitt MJ, Reynolds MA, Shiau H, Choe K, Simonsick EM, Ferrucci L: Association of periodontitis and metabolic syndrome in the Baltimore Longitudinal Study of Aging. *Aging Clin Exp Res* 2010, 22:238-242.
69. Grossi SG, Skrepcinski FB, DeCaro T, Zambon JJ, Cummins D, Genco RJ: Response to periodontal therapy in diabetics and smokers. *J Periodontol* 1996, 67:1094-1102.
70. Sheiham A, Watt RG: The common risk factor approach: a rational basis for promoting oral health. *Community Dent Oral Epidemiol* 2000, 28:399-406.
71. Batchelor P, Sheiham A: The limitations of a 'high-risk' approach for the prevention of dental caries. *Community Dent Oral Epidemiol* 2002, 30:302-312.
72. WHO: The Ottawa Charter for Health Promotion. *wwwwhoint/healthpromotion/Milestones_Health_Promotion_05022010pdf* 1986.
73. WHO: The objectives of the WHO Global Oral Health Programme (ORH). *http://wwwwhoint/oral_health/objectives/en/indexhtml*.
74. Statens Folkhälsoinstitut: Målområde 6 Halsoframjande hälso- och sjukvard. Kunskapsunderlag för Folkhälsopolitisk rapport 2010 [Health-promoting health

services - Objective domain 6] *http://wwwfhise/PageFiles/13152/R2011-29-Halsoframjande-%20halso-%20och-sjukvard-Kunskapsunderlag-for-FHPR-2010pdf* 2010.
75. Fletcher RW, Fletcher SW: Clinical epidemiology. *ISBN 0-7817-5215-9* Baltimore. Lippingcott, Williams & Wilkins 2005.
76. Graham I, Atar D, Borch-Johnsen K, Boysen G, Burell G, Cifkova R, Dallongeville J, De Backer G, Ebrahim S, Gjelsvik B, et al: European guidelines on cardiovascular disease prevention in clinical practice: full text. Fourth Joint Task Force of the European Society of Cardiology and other societies on cardiovascular disease prevention in clinical practice (constituted by representatives of nine societies and by invited experts). *Eur J Cardiovasc Prev Rehabil* 2007, 14 Suppl 2:S1-113.
77. Socialstyrelsen: Nationella riktlinjer för diabetesvården [National Guidelines for Diabetes Care] *http://wwwsocialstyrelsense/nationellariktlinjerfor diabetes varden/centralarekommendationer/screeningpreventionlevnadsvanor* 2011.
78. Socialstyrelsen: Nationella riktlinjer för sjukdomsförebyggande metoder 2011 – stöd för styrning och ledning [National guidelines for disease prevention methods in 2011 - support for governance and management, authors` translation] *http://www.socialstyrelsense/publikationer2011/2011-11-11* 2011.
79. Regeringen: Regeringens proposition 2007/08:110 En förnyad folkhälsopolitik [Government proposal 2007/08:110 A renewed public health policy]. *http://www.regeringen.se/content/1/c6/10/09/78/2ee01484pdf* 2008.
80. WHO WHO, European obot, Systems OoH, and Policies: Policy Brief; Screening in Europe. *http://www.eurowhoint/__data/assets/pdf_file/0007/108961/E88698pdf* 2006.
81. Massi-Benedetti M: The cost of diabetes Type II in Europe: the CODE-2 Study. *Diabetologia* 2002, 45:S1-4.
82. Ministry of Health and Social affairs: Public health objectives. 2004, uppdated nov 2009.
83. Rose G: Preventive strategy and general practice. *Br J Gen Pract* 1993, 43:138-139.
84. Weinehall L, Hellsten G, Boman K, Hallmans G: Prevention of cardiovascular disease in Sweden: the Norsjo community intervention programme--motives, methods and intervention components. *Scand J Public Health Suppl* 2001, 56:13-20.
85. Vartiainen E, Puska P, Jousilahti P, Korhonen HJ, Tuomilehto J, Nissinen A: Twenty-year trends in coronary risk factors in north Karelia and in other areas of Finland. *Int J Epidemiol* 1994, 23:495-504.
86. Olsson L, Svardsudd K, Nilsson G, Ringqvist I, Tibblin G: Validity of a postal questionnaire with regard to the prevalence of myocardial infarction in a general population sample. *Eur Heart J* 1989, 10:1011-1016.
87. www.norden.org/noeglehullet.
88. Norberg M, Wall S, Boman K, Weinehall L: The Vasterbotten Intervention Programme: background, design and implications. *Glob Health Action* 2010, 3.
89. Farnkvist L, Olofsson N, Weinehall L: Did a health dialogue matter? Self-reported cardiovascular disease and diabetes 11 years after health screening. *Scand J Prim Health Care* 2008, 26:135-139.

90. Pan XR, Li GW, Hu YH, Wang JX, Yang WY, An ZX, Hu ZX, Lin J, Xiao JZ, Cao HB, et al: Effects of diet and exercise in preventing NIDDM in people with impaired glucose tolerance. The Da Qing IGT and Diabetes Study. *Diabetes Care* 1997, 20:537-544.
91. Tuomilehto J, Lindstrom J, Eriksson JG, Valle TT, Hamalainen H, Ilanne-Parikka P, Keinanen-Kiukaanniemi S, Laakso M, Louheranta A, Rastas M, et al: Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* 2001, 344:1343-1350.
92. Price HC, Tucker L, Griffin SJ, Holman RR: The impact of individualised cardiovascular disease (CVD) risk estimates and lifestyle advice on physical activity in individuals at high risk of CVD: a pilot 2 x 2 factorial understanding risk trial. *Cardiovasc Diabetol* 2008, 7:21.
93. Folkhälsoenheten Landstinget Gävleborg: Rapport för 2010 Tvärsnittsstudie Hälsosamtal med 40-åringar i Gävleborg 2010. Sammanställning av riskfaktorer [Health Conversations with 40-year-olds in Gavleborg 2010, Summary of risk factors, author´s translation] *http://www.lg.se/Global/Jobba_med_oss/vardgivarportalen/Folkhalsoenheten/halsosamtalet/Rapport_riskfaktorer_Gavleborgpdf* 2010.
94. Holland WS, S. Masseria, C.: Screening in Europe. *Policy Brief* 2006.
95. WHO: Screening for type 2 Diabetes, Report of a World Health Organization and International Diabetes Federation meeting. *http://www.who.int/diabetes/publications/en/screening_mnc03pdf* 2003.
96. Tibblin G: High blood pressure in men aged 50--a population study of men born in 1913. *Acta Med Scand Suppl* 1967, 470:1-84.
97. Capewell S: Will screening individuals at high risk of cardiovascular events deliver large benefits? No. *Bmj* 2008, 337:a1395.
98. Andersson DK, Petersson C: [Screening for type 2 diabetes is justified]. *Lakartidningen* 1998, 95:5167-5170, 5175.
99. Jackson R, Wells S, Rodgers A: Will screening individuals at high risk of cardiovascular events deliver large benefits? Yes. *Bmj* 2008, 337:a1371.
100. Barger SD, Muldoon MF: Hypertension labelling was associated with poorer self-rated health in the Third US National Health and Nutrition Examination Survey. *J Hum Hypertens* 2006, 20:117-123.
101. Kottke TE, Tuomilehto J, Nissinen A, Enlund H, Piha T: Hypertension treatment without labelling effects: the North Karelia Project. *J Hum Hypertens* 1987, 1:185-194.
102. Andersson DKG: Tidig upptäckt av diabetes typ 2 är nödvändig page 24 [Early detection of type 2 diabetes is necessary, author´s translation] *ISBN:91-630-5194-X* 1997:24.
103. Andersson DK, Lundblad E, Svardsudd K: A model for early diagnosis of type 2 diabetes mellitus in primary health care. *Diabet Med* 1993, 10:167-173.
104. Zhang P, Engelgau MM, Valdez R, Benjamin SM, Cadwell B, Narayan KM: Costs of screening for pre-diabetes among US adults: a comparison of different screening strategies. *Diabetes Care* 2003, 26:2536-2542.
105. Engelgau MM, Narayan KM, Herman WH: Screening for type 2 diabetes. *Diabetes Care* 2000, 23:1563-1580.

106. Waugh N, Scotland G, McNamee P, Gillett M, Brennan A, Goyder E, Williams R, John A: Screening for type 2 diabetes: literature review and economic modelling. *Health Technol Assess* 2007, 11:iii-iv, ix-xi, 1-125.
107. Hellenius ML, Johansson J, de Faire U, Elofsson S, Krakau I: Four years experience of a cardiovascular opportunistic screening and prevention programme in the primary health care in Sollentuna, Sweden. *Scand J Prim Health Care* 1999, 17:111-115.
108. Hugoson A, Koch G, Gothberg C, Helkimo AN, Lundin SA, Norderyd O, Sjodin B, Sondell K: Oral health of individuals aged 3-80 years in Jonkoping, Sweden during 30 years (1973-2003). I. Review of findings on dental care habits and knowledge of oral health. *Swed Dent J* 2005, 29:125-138.
109. Greenwood M, Lowry RJ: Blood pressure measuring equipment in the dental surgery: use or ornament? *Br Dent J* 2002, 193:273-275.
110. Jontell M, Glick M: Oral health care professionals' identification of cardiovascular disease risk among patients in private dental offices in Sweden. *J Am Dent Assoc* 2009, 140:1385-1391.
111. ICD W: ICD http://www.who.int/classifications/icd/en/index.html.
112. Rolka DB, Narayan KM, Thompson TJ, Goldman D, Lindenmayer J, Alich K, Bacall D, Benjamin EM, Lamb B, Stuart DO, Engelgau MM: Performance of recommended screening tests for undiagnosed diabetes and dysglycemia. *Diabetes Care* 2001, 24:1899-1903.
113. WHO: Definition, diagnosis and classification of diabetes mellitus and its complications. 1999;part 1.
114. Socialstyrelsen: Hälsoekonomiskt vetenskapligt underlag Nationella riktlinjer för vuxentandvården 2011 [Health Economic Consensus Report. National guidelines for adult dental care in 2011, author´s translation] *http://www.socialstyrelsen.se/publikationer2011/2011-5-1/Documents/halsoekonomiskt-vetenskapligt-underlag-vuxentandvardpdf* 2011.
115. SAS: Statistical Analysis System http://www.sas.com/technologies/analytics/statistics/stat// factsheet.pdf (20 February 2004).
116. Bandolier: Bandolier. www.medicine.ox.ac.uk/bandolier/band59/NNT1.html #Heading5. Accessed on 15 February, 2010.
117. Frensborg: A Public Opinion Survey. Gävleborg Public Dental Service 2003.
118. (1995) The Swedish Council on Technology Assessment in Health Care: Moderately elevated blood pressure. *J Intern Med suppl 737*.
119. Sandvik E, Steine S: White coat hypertension in a general practice. Prevalence, cardiovascular risk factors and clinical implications. *Scand J Prim Health Care* 1998, 16:222-226.
120. MacDonald MB, Laing GP, Wilson MP, Wilson TW: Prevalence and predictors of white-coat response in patients with treated hypertension. *Cmaj* 1999, 161:265-269.
121. Nichols C: Dentistry and hypertension. *J Am Dent Assoc* 1997, 128:1557-1562.
122. Mancia G, Sega R, Milesi C, Cesana G, Zanchetti A: Blood-pressure control in the hypertensive population. *Lancet* 1997, 349:454-457.
123. Welin L, Svardsudd K, Tibblin G: Home blood pressure measurements--feasibility and results compared to office measurements. The study of men born in 1913. *Acta Med Scand* 1982, 211:275-279.

124. Wilhelmsen L, Berglund G, Elmfeldt D, Tibblin G, Wedel H, Pennert K, Vedin A, Wilhelmsson C, Werko L: The multifactor primary prevention trial in Goteborg, Sweden. *Eur Heart J* 1986, 7:279-288.
125. Hofsten A, Elmfeldt D, Svardsudd K: Age-related differences in blood pressure and heart rate responses to changes in body position: results from a study with serial measurements in the supine and standing positions in 30-, 50- and 60-year-old men. *Blood Press* 1999, 8:220-226.
126. Hofsten A, Elmfeldt D, Svardsudd K: Does hypertension or a previous myocardial infarction influence the blood pressure and heart rate responses to changes in body position? Results from a study with serial measurements in the supine and standing positions in 60-year-old men. *Blood Press* 2000, 9:315-322.
127. Benchimol A, Bernard V, Pillois X, Hong NT, Benchimol D, Bonnet J: Validation of a new method of detecting peripheral artery disease by determination of ankle-brachial index using an automatic blood pressure device. *Angiology* 2004, 55:127-134.
128. Directorate General for Health and Consumers DG SANCO B2 Cosmetics and Medical Devices: Directive 93/42/EEC. *http://eur-lexeuropaeu/LexUriServ/LexUriServdo?uri=OJ:C:2011:242:0008:0038:EN:PDF*.
129. Zhang P, Engelgau MM, Valdez R, Cadwell B, Benjamin SM, Narayan KM: Efficient cutoff points for three screening tests for detecting undiagnosed diabetes and pre-diabetes: an economic analysis. *Diabetes Care* 2005, 28:1321-1325.
130. Van Dyke TE, Offenbacher, S., Philstrom, B., Putt, M. S. & Trummel, C. : (1999) What is gingivitis? Current understanding of prevention, treatment, measurement, pathogenesis and relation to periodontitis. . *J Int Acad Periodontol 1:3-15*.
131. Firatli E, Yilmaz O, Onan U: The relationship between clinical attachment loss and the duration of insulin-dependent diabetes mellitus (IDDM) in children and adolescents. *J Clin Periodontol* 1996, 23:362-366.
132. Grossi SG, Skrepcinski FB, DeCaro T, Robertson DC, Ho AW, Dunford RG, Genco RJ: Treatment of periodontal disease in diabetics reduces glycated hemoglobin. *J Periodontol* 1997, 68:713-719.
133. Joshipura KJ, Rimm EB, Douglass CW, Trichopoulos D, Ascherio A, Willett WC: Poor oral health and coronary heart disease. *J Dent Res* 1996, 75:1631-1636.
134. Hujoel PP, Drangsholt M, Spiekerman C, DeRouen TA: Pre-existing cardiovascular disease and periodontitis: a follow-up study. *J Dent Res* 2002, 81:186-191.
135. Hugoson A, Ljungquist B, Breivik T: The relationship of some negative events and psychological factors to periodontal disease in an adult Swedish population 50 to 80 years of age. *J Clin Periodontol* 2002, 29:247-253.
136. Axtelius B: (1999) Social, psychological and biological determinants in periodontal disease. . *PHD Thesis Deartment of Periodontology Faculty of Odontology Malmö University, Malmö*.

137. Croucher R, Marcenes WS, Torres MC, Hughes F, Sheiham A: The relationship between life-events and periodontitis. A case-control study. *J Clin Periodontol* 1997, 24:39-43.
138. The cost-effectiveness of screening for type 2 diabetes. CDC Diabetes Cost-Effectiveness Study Group, Centers for Disease Control and Prevention. *Jama* 1998, 280:1757-1763.
139. Hoerger TJ, Harris R, Hicks KA, Donahue K, Sorensen S, Engelgau M: Screening for type 2 diabetes mellitus: a cost-effectiveness analysis. *Ann Intern Med* 2004, 140:689-699.
140. de Koning L, Merchant AT, Pogue J, Anand SS: Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. *Eur Heart J* 2007, 28:850-856.
141. Larsson B, Svardsudd K, Welin L, Wilhelmsen L, Bjorntorp P, Tibblin G: Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. *Br Med J (Clin Res Ed)* 1984, 288:1401-1404.
142. Schnohr P, Hansen AT: Mass screening for hypertension in Copenhagen supermarkets. *Lancet* 1975, 2:969-970.
143. Strychar IM, Potvin L, Pineault R, Pineau R, Prevost D: A supermarket cardiovascular screening program: analysis of participants' solicitation of follow-up care. *Am J Prev Med* 1994, 10:283-289.
144. Silverberg DS, Smith ES, Juchli B, VanDorsser E: Use of shopping centres in screening for hypertension. *Can Med Assoc J* 1974, 111:769-774.
145. Bovet P, Hirsiger P, Emery F, De Bernardini J, Rossier C, Trebeljahr J, Hagon-Traub I: Impact and cost of a 2-week community-based screening and awareness program for diabetes and cardiovascular risk factors in a Swiss canton. *Diabetes Metab Syndr Obes* 2011, 4:213-223.
146. Dettloff RW, Morse JA: Demonstration of community pharmacy and managed care organization collaboration on cardiovascular disease risk factor identification using health risk appraisal. *J Am Pharm Assoc (2003)* 2009, 49:220-222.
147. Snella KA, Canales AE, Irons BK, Sleeper-Irons RB, Villarreal MC, Levi-Derrick VE, Greene RS, Jolly JL, Nelson AA: Pharmacy- and community-based screenings for diabetes and cardiovascular conditions in high-risk individuals. *J Am Pharm Assoc (2003)* 2006, 46:370-377.
148. Peterson GM, Jackson SL, Hughes JD, Fitzmaurice KD, Murphy LE: Public perceptions of the role of Australian pharmacists in cardiovascular disease. *J Clin Pharm Ther* 2010, 35:671-677.
149. Sookaneknun P, Saramunee K, Rattarom R, Kongsri S, Senanok R, Pinitkit P, Sawangsri W, Deesin B: Economic analysis of the diabetes and hypertension screening collaboration between community pharmacies and a Thai government primary care unit. *Prim Care Diabetes* 2010, 4:155-164.
150. Toscano CM, Duncan BB, Mengue SS, Polanczyk CA, Nucci LB, Costa e Forti A, Fonseca CD, Schmidt MI: Initial impact and cost of a nationwide population screening campaign for diabetes in Brazil: a follow up study. *BMC Health Serv Res* 2008, 8:189.

151. O'Connor PJ, Rush WA, Cherney LM, Pronk NP: Screening for diabetes mellitus in high-risk patients: cost, yield, and acceptability. *Eff Clin Pract* 2001, 4:271-277.
152. Engstrom S, Berne C, Gahnberg L, Svardsudd K: Efficacy of screening for high blood pressure in dental health care. *BMC Public Health* 2011, 11:194.
153. Borrell LN, Kunzel C, Lamster I, Lalla E: Diabetes in the dental office: using NHANES III to estimate the probability of undiagnosed disease. *J Periodontal Res* 2007, 42:559-565.
154. Lalla E, Kunzel C, Burkett S, Cheng B, Lamster IB: Identification of unrecognized diabetes and pre-diabetes in a dental setting. *J Dent Res* 2011, 90:855-860.
155. FINDRISK: http://www.diabetesstiftung.de/fileadmin/dds_user/dokumente/DDS_Findrisk_englisch.pdf.
156. Silventoinen K, Pankow J, Lindstrom J, Jousilahti P, Hu G, Tuomilehto J: The validity of the Finnish Diabetes Risk Score for the prediction of the incidence of coronary heart disease and stroke, and total mortality. *Eur J Cardiovasc Prev Rehabil* 2005, 12:451-458.
157. Martin E, Ruf E, Landgraf R, Hauner H, Weinauer F, Martin S: FINDRISK Questionnaire Combined with HbA1c Testing as a Potential Screening Strategy for Undiagnosed Diabetes in a Healthy Population. *Horm Metab Res* 2011, 43:782-787.
158. Chatterjee R, Narayan KM, Lipscomb J, Phillips LS: Screening adults for pre-diabetes and diabetes may be cost-saving. *Diabetes Care* 2010, 33:1484-1490.
159. Klein Woolthuis EP, de Grauw WJ, van Gerwen WH, van den Hoogen HJ, van de Lisdonk EH, Metsemakers JF, van Weel C: Screening for type 2 diabetes in primary care using a stepwise protocol: the Diabscreen study. *Prim Care Diabetes* 2007, 1:199-202.
160. WHO International Society of Hypertension group: 2003 World Health Organization (WHO)/ International Society of Hypertension (ISH) Statement on management of hypertension. *Journal of Hypertension [2003, 21(11):1983-92]* 2003.
161. Omvik P: How smoking affects blood pressure. *Blood Press* 1996, 5:71-77.
162. Nurminen ML, Niittynen L, Korpela R, Vapaatalo H: Coffee, caffeine and blood pressure: a critical review. *Eur J Clin Nutr* 1999, 53:831-839.
163. Geleijnse JM: Habitual coffee consumption and blood pressure: an epidemiological perspective. *Vasc Health Risk Manag* 2008, 4:963-970.
164. Lakerveld J, Ijzelenberg W, van Tulder MW, Hellemans IM, Rauwerda JA, van Rossum AC, Seidell JC: Motives for (not) participating in a lifestyle intervention trial. *BMC Med Res Methodol* 2008, 8:17.
165. Sargeant LA, Simmons RK, Barling RS, Butler R, Williams KM, Prevost AT, Kinmonth AL, Wareham NJ, Griffin SJ: Who attends a UK diabetes screening programme? Findings from the ADDITION-Cambridge study. *Diabet Med* 2010, 27:995-1003.
166. Glick M: The new blood pressure guidelines: a digest. *J Am Dent Assoc* 2004, 135:585-586.

167. Glick M, Greenberg BL: The potential role of dentists in identifying patients' risk of experiencing coronary heart disease events. *J Am Dent Assoc* 2005, 136:1541-1546.
168. Sproat C, Beheshti S, Harwood AN, Crossbie D: Should we screen for hypertension in general dental practice? *Br Dent J* 2009, 207:275-277.
169. Kellogg SD, Gobetti JP: Hypertension in a dental school patient population. *J Dent Educ* 2004, 68:956-964.
170. Bandl E, Boda K, Sonkodi S: Hypertension screening in a dental surgery: a Hungarian study. *J Hum Hypertens* 1990, 4:253-257.

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