Overview of new PhDs in the Nordic Countries

Title: Healthcare priority setting and rare diseases: What matters when reimbursing orphan drugs
Candidate: Johanna Wiss
University: Department of Medical and Health Sciences, Linköping University, Sweden

Abstract:
The rarity of a disease give rise to challenges that differ from conventional diseases. For example, rarity hampers research and development of new drugs, and patients with severe, rare diseases have limited access to qualified treatments. When drugs are available, clinical evidence has higher uncertainty and the drugs can be very expensive. When setting priorities in the healthcare sector, treatments aimed at patients with rare diseases, so called orphan drugs, have become a source of concern. Orphan drugs seldom show solid evidence of effectiveness or cost-effectiveness. Still, treatments for rare disease patients has increased rapidly since the adoption of a regulation offering incentives for research and development of orphan drugs. The question arises as to whether the publicly funded health care system should provide such expensive treatments, and if so, to what extent.

This doctoral thesis aims to investigate healthcare priority setting and rare diseases in the context of orphan drug reimbursement. Priority setting for orphan drugs is located at the intersection of economic, ethical and psychological perspectives. This intersection is explored by studying the public's view on the relevance of rarity when setting priorities for orphan drugs, and by examining how orphan drugs are managed when making reimbursement decisions in practice. Also, both quantitative and qualitative methods are employed to provide a more comprehensive understanding of the topic.

Paper I shows that there is no general preference for giving higher priority to rare disease patients when the public is asked to allocate resources between rare and common disease patients. However, results show that preferences for treating the rare patients are malleable to a set of psychological factors. Paper II shows that the identifiability of an individual has no, or a negative, influence on the share of respondents choosing to allocate resources to him/her (compared to a non-identified individual). Paper III confirms that rarity per se is not seen as a factor that should influence priority-setting decisions (i.e. accept a greater willingness to pay for orphan drugs), however, other factors such as disease severity, treatment effect and whether there are treatment alternatives were seen as relevant for consideration. Paper IV explores the challenges with and solutions for orphan drug reimbursement, as perceived by different actors in five European countries.

In conclusion, priority setting for orphan drugs is complex and requires particular attention from decision makers. There are many factors to consider when making reimbursement decisions for orphan drugs. The consequences of a decision are potentially severe (both for rare disease patients and for common disease patients, depending on the decision) and psychological factors potentially influence decisions.

Title: Family, neighborhoods, and health: Conditions for the development of human capabilities
Candidate: Evelina Björkegren
University: Department of Economics, Uppsala University, Sweden

Abstract:
Essay 1: We use data from a large sample of adoptees born in Sweden to decompose the intergenerational persistence in health inequality across generations into one pre-birth component, measured by the biological parents' longevity, and one post-birth component, measured by the adopting parents' longevity. We find that most of the health inequality is transmitted via pre-birth factors. In the second part of the paper, we study the background to why children of parents with better educational attainments have better health by decomposing the association into one component attributed to the education of the biological parents and one to the adopting ones. We find that the association can mostly be attributed to the adopting parents, suggesting that parental resources per se, rather than pre-birth (genetic) differences, make up the parental education gradient in child health.

Essay 2: I use population wide data on families living in different areas in Sweden, and estimate the effects of childhood neighborhood on youth health using data on families that move across the country. Since the choice of moving and where to live is endogenous, I exploit the timing of moves and estimate the effect of siblings' different exposure time to neighborhoods. In a second approach I utilize a governmental policy that assigned refugees to their initial neighborhood in Sweden. The findings from the two strategies together imply that there are significant neighborhood effects on youth health, but there is no evidence of exposure time effects.

Essay 3: We examine birth order effects on health, and whether health at young age could be a transmission channel for birth order effects observed later in life. Our results show that firstborn children have worse health at birth. This disadvantage is reversed in early age and later-born siblings are more likely to be hospitalized for injuries and avoidable conditions. We also test for reverse causality by estimating fertility responses to the health of existing children. Overall our results suggest that birth order effects are due to differential parental investment because parents' time and resources are limited.

Essay 4: We study the short-, medium- and long-term consequences of health at birth using administrative data from Sweden for individuals born in the years 1973-1979. We contribute to a better understanding of the consequences of early life health by contrasting the effects of birth weight with two other measures of neonatal health: the length and the head circumference of the newborn. Our findings suggest that the use of birth weight alone might lead to an underestimation of the importance of early health. Furthermore, we find that there is a persistent effect of neonatal health on a variety of human capital measures in adolescence and adulthood.

Title: Causes and consequences of early-life conditions: alcohol, pollution, and parental leave policies
Candidate: Jenny Jans
University: Department of Economics, Uppsala University, Sweden

Abstract:
This thesis consists of four self-contained essays, all of which are dealing with factors that have the potential to impact the skill formation process of children.

In Essay 1, I study whether and how air pollution experienced in utero affected birth outcomes for children born in Sweden between 2002 and 2009. Combining population wide register data on birth outcomes and family characteristics with pollution data, I estimate the effect of

particulate matter (PM10) on four measures of health at birth: birth weight, low birth weight, gestational length and premature birth. The results suggests that even at the relatively low levels of pollution (in an international context), the levels were high enough to have a negative impact on birth outcomes.

Essay 2 (co-authored with Per Johansson and J Peter Nilsson) study how poor air quality affects children's respiratory health in Sweden. By exploiting so called temperature inversion episodes[1], we show that inversions significantly increases pollution levels by approximately 30%, increases children's respiratory illnesses by 5.5 percent, and increases the incidence of parents work absence, due to care of sick children, by 2.9 percent. Low-income children are particularly affected, and differences in baseline health seem to be a key mediating factor behind the SES-gap in the impact of poor air quality in this setting.

In Essay 3 (joint with Rita Ginja and Arizo Karimi) we examine how parental resources early in life affect children's health and education, exploiting the so-called speed premium (SP) in the Swedish parental leave system. The SP grants mothers higher parental leave benefits for the subsequent child without re-establishing eligibility through pre-birth market work if the two births occur within a pre-specified interval. This allow us to use a Regression Discontinuity framework. We find that the SP improves the educational outcomes of the first-born child, but not of the second-born. Impacts are driven by a combination of a positive income shock, and substitution from informal care to maternal time.

In Essay 4 (co-authored with J Peter Nilsson, Mårten Palme, Per Pettersson-Lidbom and Mikael Priks) we study how an increase in alcohol availability affects children's early-life health and later life outcomes. Exploiting the staggered expansion of alcohol sales stores in Sweden, we find that following an opening of an alcohol store infant mortality rates increase sharply. The results suggests that increases in alcohol availability influences infant mortality through changes in prenatal health, changes the composition of parents and changes the timing of birth.

Title: Essays on cognitive development and medical care
Candidate: Mattias Öhman
University: Department of Economics, Uppsala University, Sweden

Abstract:
The thesis consists of four self-contained papers. The first paper concerns fluoride in the drinking water. Many countries fluoridate the water, and concerns have been raised regarding a potential negative effect of fluoride on cognitive development. We use a large Swedish register dataset, together with unique water data, and exploit an exogenous variation of fluoride to study the causal effects. First, we find a positive effect of fluoride on dental health. Second, we find precisely estimated zero-effects on cognitive and non-cognitive ability and math test scores. Third, we find that fluoride improves labor market outcomes, indicating that good dental health is positive on the labor market.

In the second paper, I study the associations between cognitive and non-cognitive abilities and mortality using a population-wide dataset of Swedish men born between 1950 and 1965 who enlisted around age 18. I find that both cognitive and non-cognitive abilities are strongly associated with mortality, where non-cognitive ability is the best predictor. The associations are only partly mediated through income and education, and are driven by low-income earners and low-educated individuals in the bottom of the distributions.

[1] Normally, the temperature decreases with altitude, allowing air pollutants to rise and disperse. During inversion episodes warmer air at higher altitude traps air pollutants at the ground.

In the third paper, we examine how health information affects individuals' well-being. We use a regression discontinuity design on data from a screening program for an asymptomatic disease, abdominal aortic aneurysm (AAA). The information provided to the individuals is guided by the measured aorta size and its relation to pre-determined levels. When comparing individuals that receive information that they are healthy with those that receive information that they are in the risk zone for AAA, we find no effects. However, when comparing those that receive information that they have a small AAA, and will be under increased surveillance, with those who receive information that they are in the risk zone, we find a weak positive effect on well-being. This indicates that the positive information about increased surveillance may outweigh the negative information about worse health.

In the fourth paper, I estimate the effect of SSRI antidepressants on the risk of mortality for myocardial infarction (MI) patients. The effect of antidepressants on mortality is a heavily debated topic, and MI patients have an elevated risk of developing depression and anxiety. There are indications that some antidepressants may have drug-induced cardiovascular effects and could be harmful for individuals with heart problems, but there is a lack of large-scale studies using credible identification strategies. Using Propensity Score Matching, I find no increased risk of two-year mortality for MI patients using SSRI. The results are stable for several specifications and robustness checks.

Title: Essays on environmental management and economics: Public health, risk and strategic environmental assessment
Candidate: Daniel Slunge
University: Department of Economics, University of Gothenburg, Sweden

Abstract:
By analysing how people perceive and manage risks individually and collectively, this thesis aims to improve the understanding of how environmentally related welfare costs may be reduced. Papers 1–3 focus on risk perceptions and decision-making at the individual level and concern how people perceive and manage risks in relation to the increasing incidence of Lyme borreliosis (LB) and tick-borne encephalitis (TBE). The empirical analysis is based on a survey with 1500 randomly selected respondents in Sweden.

In the first paper, Learning to Live with Ticks? The Role of Exposure and Risk Perceptions for Protective Behaviour Against Tick-Borne Diseases, we analyse the role of risk perceptions and exposure for five protective measures against tick bites and the related diseases TBE and LB. We find a strong positive association between exposure and checking the skin for ticks, but no or weak associations between exposure and the use of protective clothing, tucking trousers into socks, the use of repellent or avoidance of tall grass in areas with ticks.

In the second paper, Valuation When Baselines Are Changing: Tick-borne Disease Risk and Recreational Choice, we estimate willingness to pay to avoid recreational areas with ticks, LB and TBE risk. In northern Sweden, where the presence of ticks is relatively new, the willingness to pay to avoid risk is significantly higher than in southern Sweden, where ticks are endemic. We also find that TBE-vaccinated respondents have a lower willingness to pay. These differences in willingness to pay for risk reduction between groups with different baseline risk should be taken into account when estimating welfare costs of the spread of disease vectors to new areas due to environmental and climate change.

In the third paper, The Willingness to Pay for Vaccination against Tick-Borne Encephalitis and Implications for Public Health Policy: Evidence from Sweden, we estimate the TBE-vaccination rate to 33% in TBE-risk areas and analyse the role of vaccine price, income and other factors influencing the demand for vaccination. We project that a subsidy making TBE vaccines free of

charge could increase the vaccination rate in TBE risk areas to around 78%, with a larger effect on low-income households, whose current vaccination rate is only 15% in risk areas.

Papers 4, Greening Growth through Strategic Environmental Assessment of Sector Reforms, and 5, Challenges to Institutionalizing Strategic Environmental Assessment: the Case of Vietnam, focus on risk assessment and decision-making at the collective level and concern how strategic environmental assessments are used to manage environmental risks in low- and middle-income countries. The empirical analysis is based on interviews with stakeholders involved in environmental assessments of policy reforms.

Title: Economic evaluation of mental health interventions for children and adolescents: the case of Sweden
Candidate: Mattias Persson
University: School of Business, Örebro University, Sweden

Abstract:
The focus of this thesis is economic evaluations of programs and interventions regarding children and adolescents with mental health issues, victimization, and intellectual disabilities (ID). The first paper examines a potential link between mental health issues among adolescent and the class-size of the school class they are enrolled in. The class-size and schools' financial resources is often at the center of policy debates. Our results suggest that there is no evidence that larger classes have negative impact on the mental health for adolescents in a Swedish context. The second paper investigate the societal willingness to pay (WTP) to reduce bullying in Swedish schools. The results suggest that the tax payers WTP is about 5 SEK and the societal is about 600 000 SEK per reduced bullying victim. This value of WTP could be used as a measure to evaluate different investments in anti-bullying programs and efforts to reduce the bullying in schools. The third paper estimates the cost-effectiveness of one recently introduced antibullying program, the Finnish KiVa program, one of the few evidence based programs in the world. Based on a decision-analytic model, the results indicate that the KiVa program is a cost-effective program that has a cost per reduced victim well below the WTP as estimated in the second paper as documented above. The fourth paper evaluates, from the municipality perspective, the effects of investing in a SE program compared to "business as usual" in order to increase the likelihood for gaining regular employment for the pupils with ID. The results indicate that it takes 7.5 years before breakeven is reached if investing in the SE program. The fifth paper conducts a decision-analytic economic evaluation of the SE program using simulations to assess the effects over the full life-course. The results suggest that from a societal perspective the program is cost-effective ten years after the investment and by then has generated a benefit of 17 000 SEK per individual.

Title: Socioeconomic consequences of childhood onset type 1 diabetes – a case study of the impact of an early life health shock
Candidate: Sofie Persson
University: Health Economic Unit, Faculty of Medicine, Lund University, Sweden

Abstract:
Type 1 diabetes is a lifelong, chronic disease, that generally has a sudden onset early in life, which changes the conditions for the affected child and the child's family. The overall purpose of this thesis was to explore the socioeconomic consequences of childhood onset type 1 diabetes and through this investigate how an early life health shock can affect adult socioeconomic status. The four included papers aim to capture the overall effect of type 1 diabetes on socioeconomic outcomes, such as

education, employment and earnings, during different stages in life, including adolescence, young adulthood, and midlife. The thesis also explores potential pathways through which type 1 diabetes may ultimately lead to detrimental labor market outcomes.

The analyses were performed using data from the Swedish Childhood Diabetes Register, a Swedish national research register for childhood incidence of type 1 diabetes, that has been linked to other national health data registers and socio-economic databases. Using a control group of four unique population controls, matched by year of birth and municipality of residence at the time of the diagnosis, the effect of type 1 diabetes was studied in birth cohorts born between 1962 and 1993, analyzing outcomes in ages 16 to 50 years.

The results show that the onset of type 1 diabetes, before the age of 15, negatively affects educational achievements, in both compulsory schooling and upper secondary school, as well as the final level of education. Despite developments in treatment and educational changes over time, the data indicate a persistent negative effect of type 1 diabetes on school performance also in later birth cohorts. In a longer perspective, the results show that childhood onset type 1 diabetes negatively affects employment and earnings for both women and men. The magnitude of the effect, however, depends on individual characteristics, such as gender, age at diagnosis, and disease duration. The results suggest that adult health contributes to a large proportion of the total labor market effect of type 1 diabetes, but other important factors, related to occupation, education, and family formation, also explain part of the impact on employment and earnings.

In conclusion, the findings of this thesis show that childhood onset type 1 diabetes negatively impacts socioeconomic outcomes, both early in life and in adulthood, and represents a burden that is borne both by the individual and the society. In a broader perspective, the results provide insights to how a distinct and definable shift in childhood health may translate into working life consequences.

Title: Register-based studies to assess long-term outcome in haemophilia
Candidate: Mehdi Osooli
University: Department of Translational Medicine, Lund university, Sweden

Abstract:
Introduction: Haemophilia is a X-linked bleeding disorder affecting mostly males. Women are mainly carriers of haemophilia, however, they can expereince high bleeding tendency and assocaited symptoms as with males. In the absence of the appropriate treatment, bleedings, especially into the joints, result in adverse outcomes. The general aim of this thesis was to promote the use of register-based data to investigate long-term outcomes among persons with haemophilia. In addition, we investigated some long-term ouctomes among persons with haemophilia and carriers of haemophilia using the available registers.

Methods: We conducted a scoping study and several large-scale register-based studies to evaluate outcome assessment practice and joint and survival outcomes in haemophilia, respectively. We used data from the Malmö single centre register (n=167), National Patient Register (mild haemophilia=315 and carriers of haemophilia=561) and the KAPPA register (severe haemophilia=173) as sources of inclusion of participants and data on their outcomes. Cross-sectional and longitudinal designs were used to maximize the use of available data. We investigated joint disease, haemophilia joint health score, joint surgery and survival of the study participants.

Results and conclusion: The assessment of the literature revealed a paucity of productive registers and inconsistency in their outcome reporting. Carriers and persons with mild haemophilia are at higher risk of joint disease and surgery compared to the general population. The index joints are more at risk of surgery in both groups especially among the older age groups. The KAPPA study showed remarkable health utility and joint status among younger persons with severe haemophilia

on prophylaxis started by age 3. In the Malmö register study, persons with severe haemophilia born 1980 onwards did not have surgery. This thesis suggests that carriers of haemophilia and persons with mild haemophilia are at high risk of joint disease and should be monitored at haemophilia treatment centres for their outcomes. Registers, when harmonized in terms of structure and outcome assessment, are valuable resources for generation of epidemiological evidence.

Title: Burden of disease in psoriasis and psoriatic arthritis. Occurrence, healthcare use, costs and health outcomes
Candidate: Sofia Löfvendahl
University: Department of Clinical Sciences, Lund, Lund university, Sweden

Abstract:
Psoriasis (PSO) and psoriatic arthritis (PsA) are two related chronic inflammatory diseases. A proportion of people with PSO also develop PsA. PSO and PsA seem to have multiple impacts; from the health and well-being of the individual; to the need for healthcare resources for disease management; to the loss of productivity. Compared with other chronic diseases, such as heart disease and diabetes, population-based observational healthcare research on PSO and PsA is limited.

The overall aim of this thesis was to study the impact of PSO and PsA in terms of occurrence, costs, healthcare use and patient-reported outcomes (PROs), from a population-based perspective. The included studies used data related to residents in the Skåne region, and the study populations were identified in the Skåne Healthcare register (SHR). Information was based mainly on population-based registers but also on surveys and medical records.

The point prevalence of physician-diagnosed PSO with or without PsA in the Skåne region by the end of 2010 was 1.2%, corresponding to 12,958 diagnosed individuals. The prevalence for PSO alone and PSO with PsA was 1.0% and 0.2% respectively. The ICD-10 diagnostic codes registered for PSO and PsA in the SHR showed overall good accuracy when compared to information in medical records. The annualized mean societal cost for PSO patients with PsA was 97% higher compared with PSO alone patients (€17,600 vs. €8,900). Only a minor fraction of the costs was identified as attributable to PSO and PsA specifically, indicating increased comorbidity in these patients.

Analyses on healthcare use among PSO and PsA patients, and population-based matched referents, indicated remaining disparities in the socioeconomic pattern of healthcare use, especially related to income. The effect was less accentuated for PSO and PsA compared to referents. Regarding PROs, we showed that, in a cohort of PsA patients, continuous and never users of biological drugs, which were the majority of the patients, reported better PROs and lower societal costs compare to irregular users of biological drugs.

This thesis contributes with knowledge on the impact of PSO and PsA from different perspectives, that can be useful both for researchers and policy makers. In addition, the work also adds information on data quality, and methods for prevalence and cost calculations using register-based data.

Title: Heavy metal exposure in early life - health and labour market perspectives
Candidate: Yana Pryymachenko
University: Department of Economics, Lund university, Sweden

Abstract:
This thesis consists of three empirical studies on the effects of exposure to heavy metal pollution in early childhood on a broad set of individual outcomes. The first study analyses how accumulated

exposure to metal pollution during childhood affects long-run outcomes. Exploiting policy-driven reductions in metal pollution in Sweden, it shows that accumulated exposure to metals (including cadmium, chromium, copper, lead, nickel, vanadium, and zinc) leads to lower GPA scores, fewer years of education, and reduced adult wages. It also shows that these effects may contribute to intergenerational persistence of socioeconomic status due to inequalities in pollution exposure driven by parental sorting.

The second study estimates the effect of lead pollution on infant mortality in five Sub-Saharan African countries. A sharp phase-out of leaded gasoline provides exogenous variation in changes in lead pollution between those living close to major roads and those living further away to identify a causal effect. The results show that the phase-out led to a large reduction in infant mortality, particularly among girls. This effect was driven by infants born to mothers with low socioeconomic status.

The third study investigates how exposure to lead pollution in early life affects cognitive skills among school age children in Uganda. Again, it relies on the phase-out of leaded gasoline as an exogenous shock to lead pollution levels. The findings suggest a strong negative effect of lead pollution on math and English test scores, which is stronger for children exposed to lead pollution at an earlier age.

Taken together, these studies contribute to our understanding of the benefits of more stringent environmental regulations regarding heavy metal pollution.

Title: From cradle to grave: Empirical essays on health and economic outcomes
Candidate: Elvira Andersson
University: Department of Economics, Lund university, Sweden

Abstract:
This thesis contains four independent research papers, which investigate the causal relations between several aspects of health and economic outcomes at different stages of the life course. The first paper investigates the causal effects of maternal deprivation and maltreatment during various periods of childhood on adolescent health and human capital. Using hospital data and information on ninth year GPA for the entire Swedish population born in 1978-1995, we exploit between-sibling variation in the age at exposure to maternal psychiatric hospitalization. Our results indicate a greatly elevated risk of hospital admission due to self-harm and substance-related diagnoses during late adolescence among individuals exposed to maternal psychiatric hospitalization in childhood. We also find a relatively small negative impact on girls' ninth year GPA. Taken together, the results suggest substantial adverse effects on psychosocial health for individuals exposed to maternal psychiatric hospitalization during childhood. The detrimental effects on child health are especially pronounced for exposure at very early ages, especially for boys.

The second paper uses draft data covering the entire population of Swedish males born in 1965-1975 to study visually impaired individuals' labor market outcomes. A detailed and objective measure of visual acuity lets me distinguish visually impaired individuals whose impairment comprises a work-limitation from those whose productivity remains unaffected. Together with detailed information on occupational categories, this allows me to separate effects of work limitations and selection into professional categories from consequences of discrimination due to wearing glasses. The data contains objective information on cognitive and non-cognitive ability and general health, allowing me to investigate the role of important mediators. While I do not find any evidence of discrimination against individuals wearing glasses, my results suggest that work-limitations adversely affect visually impaired individuals' employment rates and earnings, already at a Jow level of reduced vision after optimal correction. I also show the importance of, most notably,

non-cognitive ability in explaining part of the labor market disadvantage, suggesting difficulties for visually impaired individuals in acquiring this type of skills.

The third paper uses Danish day care teachers as an ideal case for analyzing whether or not work pressure, measured by the child-to-teacher ratio, that is, the number of children per teacher in a day care institution, affects teacher sickness absenteeism. We control for individual teacher characteristics, workplace characteristics, and family background characteristics of the children in the day care institutions. We perform estimations for two time periods, 2002-2003 and 2005-2006, by using generalized method of moments with lagged levels of the child-to-teacher ratio as an instrument. Our estimation results are somewhat mixed. Generally, the results indicate that the child-to-teacher ratio is positively related to short-term sickness absence for teachers working with 1/2-3-year old children, but not for teachers working with 3-6-year olds.

In the fourth paper, we study the short-run effect of salary receipt on mortality among Swedish public sector employees. By exploiting variation in paydays across work-places, we completely control for mortality patterns related to, for example, public holidays and other special days or events coinciding with paydays and for general within-month and within-week mortality patterns. We find a dramatic increase in mortality on the day that salaries arrive. The increase is especially pronounced for younger workers and for deaths due to activity-related causes such as heart conditions and strokes. The effect is entirely driven by an increase in mortality among low-income individuals, who are more likely to experience liquidity constraints. All things considered, our results suggest that an increase in general economic activity on salary receipt is an important cause of the excess mortality.

Title: Health economic evaluations of screening programs - Applications and method improvements

Candidate: Mattias Aronsson

University: Department, University and country: Department of Medical and Health Sciences, Linköping University, Sweden

Abstract:

Screening to detect diseases early is attractive as it can improve the prognosis and decrease costs, but it is often a problematic concept and there are several pitfalls. Many healthy individuals have to be investigated to avoid a disease in a few, which results in a dilemma because to save a few, many are exposed to a procedure that could potentially harm them. Other examples of problems associated with screening are latent diseases and over-treating. The question of optimal design of a screening program is another source of uncertainty for decision-makers, as a screening program may potentially be implemented in very different ways. This highlights the need for structured analyses that weigh benefits against the harms and costs that occur as consequences of the screening.

The aim of this thesis is, therefore, to explore, develop and implement methods for health economic evaluations of screening programs. This is done to identify problems and suggest solutions to improve future evaluations and in extension policy making.

This aim was analysed using decision analytic cost-effectiveness analyses constructed as Markov models. These are well-suited for this task given the sequential management approach where all relevant data are unlikely to come from a single source of evidence. The input data were in this thesis obtained from the published literature and were complemented with data from Swedish registries and the included case studies. The case studies were two different types of screening programs; a program of screening for unknown atrial fibrillation and a program to detect colorectal cancer early. Further, the implementation of treatment with thrombectomy and novel oral anticoagulants were used to illustrate how factors outside the screening program itself have an impact on the evaluations.

As shown by the result of the performed analyses, the major contribution of this thesis was that it provided a simple and systematic approach for the economic evaluation of multiple screening designs to identify an optimal design.

In both the included case studies, the screening was considered cost-effective in detecting the disease; unknown atrial fibrillation and colorectal cancer, respectively. Further, the optimal way to implement these screening programs is dependent on the threshold value for cost-effectiveness in the health care sector and the characteristics of the investigated cohort. This is because it is possible to gain increasingly more health benefits by changing the design of the screening program, but that the change in design also results in higher marginal costs. Additionally, changes in the screening setting were shown to be important as they affect the cost-effectiveness of the screening. This implies that flexible modelling with continuously updated models are necessary for an optimal resource allocation.

Title: Health and health-behavior responses to macroeconomic shocks
Candidate: Thorhildur Ólafsdóttir
University: Faculty of Economics, University of Iceland, Iceland

Abstract:
Individuals demand health capital for its consumptive and investment aspects. Being free from illness and injury directly increases utility and increases healthy time available for household and market production, consequently raising earnings. During the course of life, individuals produce health by means of goods and services from market together with their own time and as such, health is produced within the household. Relative price changes of the arguments in an individual´s health production function thus affect his/her choice of inputs and consumption, possibly resulting in a substitution between market production and household production. A shock to the macroeconomy, characterized by a recession or a boom is likely to affect the relative prices of inputs demanded for health production through changes in the wage rate, total income or work hours. This dissertation is comprised of three papers where a behavioral- and a health response to macroeconomic changes is explored with the aim of studying whether and how changes in the macroeconomy affect health behaviors and physical health.

The first paper examines whether smoking behavior in Iceland was affected by the economic collapse in 2008 and furthermore, the possible role of income and work hours as pathways is explored. The detected reduction in smoking participation and smoking intensity is not explained by the changes in labor-market variables. Other factors in the demand function for tobacco play a more important role; real price changes being the most notable.

The second paper examines whether drinking behavior in Iceland was affected by the economic collapse in 2008 by exploring drinking behavior across gender and types of drinkers. Women were found to decrease their frequency of any alcohol consumption and frequency of binge drinking more than men between waves but men showed a stronger negative response to the crisis in binge drinking participation and alcohol dependence. Changes in individual income explain most of men´s reduction in drinking, but women´s drinking responses are not operating through labor-market mechanisms to the same extent. As in the first paper, a real price increase of alcohol seems to play an important role in explaining the reduction in drinking pre- to post the crisis for women in particular.

The third paper examines whether a short-term increase in labor supply affects the probability of acute myocardial infarctions (AMI), commonly known as heart attacks. The results support the prominent hypothesis of short-term increased work as a mechanism explaining worsening heart health in upswings, for men aged 45-64 who were self-employed. We furthermore

find a larger increase in the probability of AMIs during the tax-free year among men aged 45-54 than men aged 55-64.

Title: Economic evaluations in adopting new vaccines in the Finnish national vaccination programme

Candidate: Heini Salo

University: Department of Public Health, University of Helsinki, Finland and Department of Health Protection, National Institute for Health and Welfare, Finland

Abstract:

This study presents the materials, methods, and results of the economic evaluations of 7-valent pneumococcal conjugate vaccination (PCV7) programme, influenza vaccination programme and human papillomavirus (HPV)-associated cost of illness study, all of which were used in the vaccine adoption decision-making process in Finland in 2001–2011. Vaccinations of all children aged 6–36 months with influenza vaccine were accepted into the NVP in 2007, infant pneumococcal vaccinations in 2010 and HPV vaccinations of all girls in 2013.

When a new vaccine is considered for inclusion into the NVP in Finland the expected public health benefit, the safety of the vaccine for an individual, the safety of the vaccination programme at the population level, and the cost-effectiveness of the vaccination programme are evaluated. An economic evaluation is needed to support the decision-making process. The decision-makers have not specified an explicit range of cost-effectiveness threshold values below which an intervention would automatically be accepted and lead to funding.

In the first economic evaluation of the infant PCV7 vaccination programme (excluding indirect herd effects) the cost per QALY gained was EUR 54 600. In the economic re-evaluation, including the indirect herd effects of the vaccination programme in older age groups reduced the cost per QALY gained to EUR 20 600.

The children's influenza vaccination programme was found to yield cost savings from the health care provider perspective. The vaccination programme was estimated to save annually EUR 7.6 per vaccinated child aged 0.5–4 years when the assumed vaccine efficacy was 60%.

In Finland, there is a considerable annual disease burden of HPV-related genital disease in the female population. Most of it is detected by the 446 000 annual screening tests, 55% of which are carried out as opportunistic tests. The opportunistic tests account for 71% of the total of EUR 22.4 million screening costs. Further diagnostics, management and treatment of HPV-related genital disease resulted in an additional cost of EUR 22.3 million, of which the costs of less severe HPV-related disease manifestations were EUR 15.5 million.

Considering all tests taken both within and outside the organised programme, the 5-year coverage of Pap testing in Finland was 87% among women aged 25 69 years. At present, the successful reduction in the cervical cancer incidence and mortality is due to tests taken both within and outside organised screening. Opportunistic Pap testing both substitutes and overlaps with the tests taken within the organised programme. In order to be able to coordinate organised and opportunistic Pap testing without losing the high coverage, it is essential to establish a nationwide Pap test register. Such a register is necessary for the effective and cost-effective secondary prevention of cervical cancer, which will be needed in both unvaccinated and vaccinated populations.

Title: Bilateral effects between health expenditures, health outcomes and economic growth: Evidence from time series and panel granger non-causality tests
Candidate: Arshia Amiri
University: Department of Health and Social Science, University of Eastern Finland, Finland

Abstract:
The major research questions of dissertation are related to the potential bilateral positive impacts between investment in human capital resources in the formation of health and national income. From theoretical point of view these relationships can be either in both directions. However the empirical results are inconclusive. To prepare precise information about the predictable relationships between health variables and economic activity, the method of Granger non-causality tests is used in this context. Studies 1 and 2 examine time series and panel data Granger causality between health care expenditure and Gross Domestic Product per capita (GDPc) in OECD countries in years 1970 – 2012. The analysis is conducted with two modified versions of Granger non-causality tests. The test results indicate that bidirectional causal relationships are predominant. Study 3 tests for panel data Granger non-causality between HIV/AIDS mortality and GDPc in 44 African countries in years 1970 – 2012. The results highlight the predictable relationship from mortality to GDPc. Study 4 investigates Granger causality – both in panel data and at country level – between child health and economic growth in a sample of 175 countries in years 1990 – 2014. The results indicate that relationships run in both directions. Interestingly, the impact of economic growth on child health growth is more frequent in lower income countries relative to high income countries. Study 5 analyses relationship between life expectancy at older ages and GDPc in OECD countries in years 1970 - 2012. Results demonstrate that these variables are co-integrated, and bilateral causal relationship is present in 65% of total countries. Overall, obtained results alert economists about the risk of endogeneity bias and specification errors in empirical analyses which aim to define the relationships between health variables and GDPc.

Title: Physician quality and financial incentives
Candidate: Anne Sophie Oxholm
University: Centre of Health Economics Research (COHERE), Department of Business and Economics, University of Southern Denmark, Denmark

Abstract:
This dissertation consists of four self-contained chapters focusing on physicians' supply of health care. The first chapter addresses the importance of the quality of physicians' chronic disease management for patients' health. Following an instrumental variable approach, we instrument the quality of chronic-disease treatment by the physician's propensity to follow clinical guidelines. Our results show that the patients who receive high-quality care from their physician experience a health improvement. The results of this chapter serve as motivation for investigating how physicians can be incentivised to improve the quality of care. Chapters 2 and 3 focus on physicians' response to target-based pay for performance schemes. The chapters show that physicians' response to target-based performance payment depends on their type (determined by abilities and preferences), the payment size, and uncertainty about their own performance. Therefore, the designers of such payment schemes should conduct baseline evaluations to assess the distribution of the physicians' types and their ability to predict own performance. Pay for performance schemes are often introduced on top of the existing remuneration schemes, causing a rise in health care costs. To control the rising costs, some payers turn to alternative payment schemes, such as capitation-based payments. Capitation is an ex-ante lump-sum payment per patient registered with the physician. This scheme is popular because it ensures the payers' budget security. One drawback of capitation-based

schemes is that they give physicians an incentive to reduce the number of services they provide to their patients, thereby leading to less than the patient-optimal level of care. Previous studies find that especially high-need patients suffer from an under-provision of care in capitation-based schemes. The fourth and final chapter uses a controlled laboratory experiment with medical students to test whether the design of capitation-based payment schemes affect physicians' prioritisation of patients. We find that the design of capitation-based payment schemes can affect physicians' allocation of care to different patient types. The findings of chapters 2-4 highlight the importance of payment scheme design for the physicians' supply of health care.

Title: The importance of epidemiological predictors for healthcare costs for chronic patients: A case study on osteoporotic fracture patients

Candidate: Louise Hansen
University: Department of Business and Management, Danish Center for Healthcare Improvements, Aalborg University, Denmark

Abstract:
Healthcare systems around the world continue to see their expenditures increase, measured as a percentage of gross domestic product. Within health economics, the need for models that can predict healthcare costs is of substantial importance, as decisions to introduce as well as to decommission healthcare services are based on these. This dissertation is an attempt to highlight the importance of epidemiological factors for health economic research on chronic diseases. Hence, the research question of interest is: how do individual epidemiological and behavioural factors impact the healthcare utilisation of patients with a chronic disease, e.g. osteoporosis?

This dissertation proposes a framework for predicting healthcare utilisation which includes four steps: familiarisation with the study population, determining the appropriate resource use, determining which predictors are important to consider, and lastly choosing the most appropriate statistical model. This framework was developed as a result of five quantitative studies, of which four were based on patient specific data from registers, and one on cost of illness theory. The framework was applied for predicting the cost for all fractures patients in one year following the fracture, i.e. the fifth study included in this dissertation. This study showed that it is not only important to understand the population of interest, as this eases the subsequent identification of potential predictors, but also the healthcare system through which these patients are treated, as different resources were affected differently by the clinical and behavioural predictors included.

In conclusion, the results from this dissertation highlight the importance being familiar with the population of interest, identifying the relevant resources, including both epidemiological and behavioural predictors, when analysing outcomes from both an epidemiological and health economic perspective, and choosing the right statistical model to analyse all this with. Both health and social scientists interested in researching utilisation of healthcare should consider these four steps.

Title: Health economic evaluation of telehealthcare: Can we include "why" and "under what circumstances" telehealthcare is cost-effective in health economic evaluation?
Candidate: Flemming Witt Udsen
University: Department of Business and Management, Danish Center for Healthcare Improvements, Aalborg University, Denmark

Abstract:
This thesis contains the results from the Danish TeleCare North trial meant to assess the effectiveness and cost-effectiveness of a telehealthcare solution implemented in North Denmark Region from 2013-2015. The TeleCare North trial demonstrated no difference in health-related quality of life and the telehealthcare solution was not cost-effective for all included COPD patients. But there was a potential to target the solution to patients with severe COPD. The results also indicate that implementation could have a strong impact on cost-effectiveness, more so than health- or socio-demographic factors.

The results from the TeleCare North trial were used directly in a national decision to implement the telehealthcare solution to patients with severe COPD in Denmark and lead to considerable debate nationally. This debate could be viewed as an actual account of the usefulness of health economic evaluation for decision making meant to inform adaptation of the health economic evaluation approach.

Based on developments in realist evaluation and experiences with conducting the evaluation of TeleCare North, four principles for health economic evaluation of complex telehealthcare interventions is outlined in order to facilitate future health economic designs of telehealthcare that should ultimately answer if telehealthcare is cost-effective, for whom, why and under what circumstances.

Title: Using quality indicators in health economic evaluation to establish the value for money of quality improvements
Candidate: Anne Sig Vestergaard
University: Department of Business and Management, Danish Center for Healthcare Improvements, Aalborg University, Denmark

Abstract:
Quality improvement is increasingly used in the healthcare sector in an attempt to, amongst other things, contain the increasing resource use. Health economic evaluation informs on the efficient use of resources and hence could provide valuable information on the value for money of quality improvements. However, in quality improvement, quality indicators are often favored for assessment of the impact of interventions. As quality indicators do not necessarily represent an impact on health, per se, this constitutes an obstacle for the economic evaluation of quality improvements. In addition, there are appreciable differences in the aims and epistemologies of economic evaluation and quality improvement. Economic evaluation is intended to inform on the value for money of interventions and evidence on the value of interventions is often derived from evidence-based medicine. In contrast, quality improvements may target other aspects of healthcare than the efficient allocation of resources and evidence is acquired through a multiplicity of methods from different scientific disciplines. These discrepancies constitute substantial barriers to the application of economic evaluation of quality improvements. In consequence, establishment of their value for money may be hampered. The lack of knowledge on the cost-effectiveness of quality improvements may indirectly harm patients by causing opportunity costs – either because cost-effective quality improvements are not implemented or because cost-ineffective interventions are employed.

The present dissertation presents a contribution as to how quality indicators may be employed to estimate the value for money of quality improvements, when evidence on their impact on patient-relevant outcomes is not available. In a framework founded in Bayesian decision theory and value-of-information analysis, quality indicators may be introduced as intermediate links between interventions and patient-relevant outcomes, thereby enabling estimation of the cost-effectiveness of quality improvements. A set of requirements for quality indicators to be applicable in the context of economic evaluation is propounded. These lead to the presentation of a set of methodological considerations, which should be made when studies in quality improvement are designed and economic evaluation is projected.

The empirical case for the present dissertation and the appended papers is within the clinical field of cardiology, specifically on stroke prophylaxis in nonvalvular atrial fibrillation through the use of oral anticoagulant therapy. The focal point of the papers is to evaluate the health economic potential of alternative approaches to improving stroke prophylaxis for this patient population, not focusing on evaluation of one pharmacological treatment versus another.

Title: A framework for identifying disease burden and estimating health-related quality of life and prevalence rates for 199 medically defined chronic conditions

Candidate: Michael Falk Hvidberg
University: Department of Business and Management, Danish Center for Healthcare Improvements, Aalborg University, Denmark

Abstract:
In recent decades, there has been a shift in disease patterns towards chronic disease. Along with an ageing population, people live longer with chronic disease, including an often decreased health-related quality of life (HRQoL). The rising burdens of chronic conditions put economic pressures on the health-care system. Experts have forecasted that the rising budget burdens are not sustainable unless action is taken. Thus, there is a need for prioritization and health economic evaluation if existing universal health-care systems are to be sustained. However, there is a shortage of comparative data providing an overview of the burdens of chronic conditions in terms of both size and severity, and standardized data that can be used within health economic evaluation and research.

The dissertation aims to support future health economic evaluation, decision-makers but also other health-care related research. It provides a framework for identifying 199 chronic conditions within health registers (objective 1), which can be used for different outcomes and research areas. Moreover, the thesis provides prevalence estimates of chronic conditions (objective 2) in order to give estimates of the size of a problem. However, as size may not give any indication of the severity of a condition, estimates of HRQoL are crucial too. Thus, HRQoL based on EQ-5D 3L preference scores – which is the burden measure preferred within health economic evaluation – are calculated (objective 3) based on new, complex regression methods. Finally, a case example of HRQoL analytics of a survey-based chronic condition in contrast to register-based definitions is presented (objective 4).

The results are expected to have several implications within priority settings. The estimates could help in setting priorities for resource allocation within health services, prevention and research in mainly two ways. First, the estimates of size and severity may provide information useable in policy setting generating an awareness and overview of potential issues. Secondly, the estimates can be used in health economic evaluation to assist decision-makers in concrete resource allocation and prioritization. The framework can also be used for monitoring trends in population health as well as monitoring policies such as, e.g. compulsory regional and local health agreements. However, in regard to the second point, the estimates themselves do not provide information about competitive

alternatives or interventions and recommendations for decision makers. Thus, using the estimates within cost-effectiveness analysis (CEA) is crucial.

This dissertation delivers a register-based framework for identifying chronic conditions and complementing estimates of quantity/size (by prevalence) and severity (by EQ-5D HRQoL) for use in health economic evaluation and other research. Thus, the aim is not to provide any specific recommendations for decision-makers, but simply to provide the means for others to do so.

Title: Implementing clinical practice guidelines into everyday practice - potentials and pitfalls

Candidate: Cathrine Elgaard Jensen
University: Department of Business and Management, Danish Center for Healthcare Improvements, Aalborg University, Denmark

Abstract:
Low back pain is the leading cause of years lived with disability and the ninth most prevalent disorder worldwide and thus a major burden for the individual patient as well as for society. In Denmark, the annual health care costs related to the disorder amount to 1.8 billion Danish kroner (DKK) and an additional DKK 4.8 billion due to lost productivity. Despite only minor changes in the central recommendations for management of low back pain in general practice, evidence has shown a wide gap between what is recommended and what is observed. In connection with the publication of the regional guideline for low back pain management in the North Denmark Region, a cluster randomised controlled clinical trial with an alongside economic evaluation was carried out.

The primary aim of this academic dissertation was to evaluate the cost-effectiveness of a multifaceted implementation strategy to increase general practitioners' use of guideline recommendations. More specifically, to evaluate whether the additional upfront costs of the multifaceted implementation strategy in comparison with a usual strategy of dissemination were counterbalanced by improvements in quality-adjusted life years for patients with low back pain where there were no signs of serious underlying pathology. The results from the economic evaluation showed that the multifaceted implementation strategy offered a cost saving, however, there was a risk of a modest loss in quality-adjusted life years. A probabilistic sensitivity analysis, furthermore, showed that the results were sensitive to change in the included parameters. Local decision makers must assess if the cost saving justifies the risk of a modest loss in quality-adjusted life years, i.e. whether the multifaceted implementation strategy can be considered good value for money.

As a secondary aim in this academic dissertation, principal-agent theory was applied to explain the general practitioner's role as double agent when using clinical practice guidelines in everyday practice. General practitioners have to take into account both the interests of the individual patient as well as the interests of other and future patients, which can impact the implementation of clinical practice guidelines in the situations where the general practitioner is unable to reconcile the preferences of these two principals. The principal-agent theory was, likewise, a useful theoretical framework for understanding that pushing general practitioners to implement clinical practice guidelines in some situations risk harming the relationship between the general practitioner and the patient as well as create opposition towards the concept of clinical practice guidelines as these may be viewed as evidence tyranny rather than assisting physician-patient decision making. Going forward, it is important to acknowledge and facilitate the general practitioner's role as double agent to increase implementation of clinical practice guidelines in everyday practice.

Title: Social protection, health risk, and household welfare in Zambia
Candidate: Peter Hangoma
University: Centre for International Health, University of Bergen, Norway

Abstract:
Households in sub-Saharan Africa face substantial health risk (illness, injury, death), threatening their welfare and predisposing them to deeper poverty. This is worsened by low penetration of social protection. Substantial inequalities also exist were households from poorer socioeconomic backgrounds, apart from having lower access to social protection, face a higher share of health risk. My PhD thesis focused on Zambia and consists of three sub-studies. The first investigated the effect of injury on consumption, earned income, medical spending, and coping strategies. Understanding these mechanisms and how different socioeconomic groups are affected is important for the design of social protection schemes. It is the first study to investigate the effect of injury on all these outcomes, and at a national level. Findings show that injury was associated with reduced consumption, increased medical spending, and reduced earned income. To cope with risk, households relied on informal borrowing and selling assets. Middle-income household were particularly vulnerable suggesting that current efforts to scale up social protection schemes should move beyond the poorest households.

In the second sub-study, we evaluated the short- and long-term impact of the removal of user fees for health services on access to health services and medical spending. Improving access to health services is critical in poor countries where a large section of the population suffers from ill-health, live on bare subsistence, and are more likely to impoverished through medical spending. We build on the existing literature by showing that observed increases in utilization of public facilities are due to increases in overall use of health services, and not merely a shifting of care seeking from private to public facilities. Overall use increased more for individual from lower socioeconomic backgrounds. We concluded that such improvements in utilization would not improve health if quality of care is not improved. We also show counterintuitive evidence that the policy did affect medical spending significantly. These effects were sustained in the long term.

In the third sub-study, we investigated determinants, and changes in inequality, of childhood ill-health during the period of massive scale up of child interventions in the run up to the 2015 target of the Millennium Development goal on child health. Although on average, there was an improvement in child health outcomes, socioeconomic inequality in childhood ill health, specifically stunning and fever, increased. The increases in inequality were driven both by changes in inequalities of the determinants of child health, e.g., wealth, mother's education, birth order, etc, and the fact that the relationship between these determinants and child health was strengthened, yet these determinants still remained concentrated on the well-off. Reducing inequality in the determinants of childhood is key to reducing inequalities in childhood health risk.

Title: Ageing, mortality and health care expenditures. The case of Norwegian hospitals and ambulances
Candidate: Fredrik Alexander Gregersen
University: Institute of Clinical Medicine, Faculty of Medicine, University of Oslo, Norway

Abstract:
In order to predict future health care expenditures and to understand the current financial situation, key variables that drive the expenditures have to be estimated. The aim of this thesis is to identify and estimate the impact of variables driving the health care expenditures within secondary care—in

particular, the impact of age and mortality. Both the hospital expenditures and the emergency services are examined.

In order to quantify the impact of mortality and age on the expenditures, data covering all inpatient hospital admissions in Norway from 1998 to 2010 and all ambulance transports for the South-Eastern Regional Health Authority (Helse Sør-Øst) for 2009 and 2010 were applied. For hospitals, both age and mortality are suggested to drive current hospital expenditures. For ambulances, distance to hospitals and age are central in explaining the variation in costs. For hospitals and ambulances, health care expenditures are found to be higher for newborns and the elderly as compared to the rest of the population.

We estimate that approximately 10% of total hospital expenditures are allocated to decedents within a calendar year. With data from 2010, the share is estimated to be 10.6% (for inpatient and outpatient care), while with data from 1998–2009, the estimated share is 9.0% (for inpatient care). Furthermore, our analysis suggests that mortality-related hospital expenditures are a decreasing function of age.

The connection between the concepts of steepening and the red herring hypothesis are also discussed. The red herring hypothesis states that it is time to death and not age per se that drives health care expenditures, while steepening states that health care expenditures grow faster for the elderly population than the rest of the population over time. The two concepts are found to be independent. The empirical analyses also suggest that steepening is present for the Norwegian hospital sector for the time period 1998–2009 if newborns are excluded. Furthermore, I put forth the hypothesis that steepening will be present for countries with high per capita health care expenditures in periods of increased per capita expenditures.

Title: Activity-based financing, primary care capacity, and hospital use among the elderly in Norway

Candidate: Jun Yin

University: Institute of Health and Society, Faculty of Medicine, University of Oslo, Norway

Abstract:

The aim of the thesis is to investigate how activity-based financing and primary care capacity influence hospital use by the elderly. Our data sources comprise two national registries from 2000-2007: the Norwegian Patient Registry and Statistics Norway.

We first examine whether increasing the activity-based component provides hospitals with an incentive to systematically reduce the length of stay in hospitals (Paper 1: The effect of activity-based financing on hospital length of stay for elderly patients suffering from heart diseases in Norway) and increase the readmission rates for elderly patients (Paper 2: The influence of changes in activity-based financing on hospital readmissions for the elderly). We then explore whether increasing the primary care capacity reduces three indicators of hospital use; length of stay, number of admissions and hospital activity measured by the number of DRG points (Paper 3: The influence of primary care capacity on hospital use among the elderly).

Our findings indicate that increasing the activity-based component reduces length of stay for elderly patients suffering from heart diseases, but the effect is small. The overall 30-days readmission rate for acute care elderly patients suffering from the 14 most common diagnoses is 6.6%. We show that activity-based financing has no significant effect on the readmission rate. However, patient characteristics do predict the readmission rate. We also identify a negative association between resource use in primary care and length of stay, and positive associations between primary care capacity and the number of admissions and the number of DRG points.

Title: Economics of non-communicable disease prevention: Cost-effectiveness and equity impact of primary prevention of cardiovascular disease in Tanzania

Candidate: Frida Namnyak Ngalesoni

University: Department of Global Public Health and Primary Care, Faculty of Medicine and Dentistry, University of Bergen, Norway

Abstract:

Non-communicable diseases (NCD) in general and cardiovascular disease (CVD) in particular are traditionally not prioritised in Tanzania due to the high burden of communicable diseases; yet, the literature points towards a rising prevalence of their risk factors. If these trends are to be halted and reversed, higher priority may need to be given to NCD prevention.

The primary objective of this study is to generate evidence on the cost, cost-effectiveness and equity impact of CVD primary preventive strategies. A total of four papers made up this thesis. For Paper I, a cost analysis study, cost data were collected in urban and rural Tanzanian settings. An ingredients was employed in the identification and measurement of resource use and valuation followed the opportunity-cost method. Patient costs were collected using a standard questionnaire and analysed using STATA. Paper II - a modelling study - compared several pharmacological drugs for the prevention of CVD, adopting a narrow societal perspective. The results of Paper I served as cost data inputs while other model inputs were obtained from the literature. Paper III, employed modelling techniques to assess the efficiency and inequality impact of two different CVD preventive approaches. Inputs to this paper were provided by the results of Papers I and II. Paper IV used an Excel-based Markov model to analyse five demand-side tobacco control strategies following a government perspective. Cost data were collected from relevant government organisations and other model inputs were taken from the literature.

The costing paper revealed that the provision of primary prevention of CVD in Tanzania is costly. The unit cost of providing CVD medical primary prevention services ranged from US$ 30–71 per patient per year depending on health facility location and level. Patient costs of receiving these services were also substantial. We estimated an average of US$ 118 and US$ 127 per year for urban and rural patients, respectively. We then demonstrated that a number of these interventions effectively reduce CVD risk, and are cost-effective for most CVD risk levels, especially for patients with diabetes. The study also found that preventing CVD based on differentiating risk threshold by age is a better alternative than the World Health Organisation's single risk threshold approach when both efficiency and inequality are considered important. At the population level, tobacco control through increases in taxes was the least expensive and the most cost-effective strategy in the prevention of CVD.

Even though the cost of medical primary prevention of CVD is high, providing these interventions represents value for money for most CVD risk levels. The best provision approach seems to be a differentiated risk threshold approach. At the population level, an increase in tobacco taxes is the most cost-effective measure for preventing CVD in Tanzania.