## Health care costs & laboratory expenditures

The cost of health care in Sweden, as well as in many other countries, increases every year [21, 22, 112], and more rapidly so than the GDP [113]. In 2001, the net costs of health care in Sweden were €14 106 million (inflation-adjusted according to the consumer price index in 2008 euros). By 2008, the total expenditure had reached €20 640 million [114]; an increase by over 46% in only seven years [115]. The GDP, on the other hand, had during the same period only increased by approximately 20% [116]. The costs of health care in Sweden, expressed as a percentage of GDP, were in 2005 9.2% [117], which is slightly above the 8.9% average of the OECD-countries [118]. That puts Sweden in 11th place (see Table 1), spending a significantly lower percentage of GDP on health care compared to the top-ranked United States, which spent 15.2% of GDP on health care in 2005 [118].

Table 1. Total expenditure on health care expressed as a percentage of GDP.

| Rank | Country | % of GDP spent on health care |
|---|---|---|
| 1 | United States | 15.2% |
| 2 | Switzerland | 11.4% |
| 3 | France | 11.1% |
| 4 | Germany | 10.7% |
| 5 | Belgium | 10.6% |
| 6 | Austria | 10.3% |
| 7 | Portugal | 10.2% |
| 8 | Canada | 9.9% |
| 9 | Denmark | 9.5% |
| 10 | Iceland | 9.4% |
| 11 | Sweden | 9.2% |
| 12 | Norway | 9.1% |
| 13 | Greece | 9.0% |
| 14 | Italy | 8.9% |
| 15 | Australia | 8.8% |

Of the total health care costs, laboratory expenditures only account for approximately 4% in Sweden [119]. The corresponding figures are 20% in the United States, 4% in the United Kingdom, 5.2% in Australia, and 7–10% in Canada [120]. In 2000, the total annual cost of laboratory testing in Sweden was estimated at approximately €0.7 billion, half of which was constituted by the costs of clinical chemistry tests [50], the largest of the laboratory medicine subspecialties.

Although they only account for a very small part of the total health care costs, the laboratories are often among the first disciplines to be targeted for budget reductions as their costs are easily discernable. However, the impact of laboratory test utilization on health care as a whole is widespread and the monetary value of the effects are difficult to measure.

## IBD and IBS

An illustrative example of the effects that laboratory test utilization may have on associated health care costs is in the differential diagnosis between Inflammatory Bowel Disease (IBD) and Irritable Bowel Syndrome (IBS) through the use of the laboratory test F-calprotectin.

IBD, which includes Crohn's disease (CD) and ulcerative colitis (UC), and IBS are both chronic gastrointestinal disorders that share the characteristic symptoms of, among others, abdominal pain, bloating, and altered bowel habits [121]. Although they have many key symptoms in common, IBD and IBS are fundamentally different as the former is organic and the latter functional in character. The functional gastrointestinal disorders, of which IBS is the most common, account for up to 40% of referrals to gastroenterologists, and are characterized by gastrointestinal symptoms that cannot be explained by structural or biochemical abnormalities [122]. Up to 22% of the population in North America is reported as having symptoms of IBS, and the prevalence is similar in Japan and China [123]. In comparison, the prevalence rates of CD and UC in Europe range from 8.3 to 214 and from 21.4 to 243 per 100 000 people, respectively. In North America the prevalence rates of CD range from 26.0 to 198.5 and for UC from 37.5 to 246 per 100 000 people [124]. IBD was previously most common in the Western world, but is now increasing in incidence in other parts of the world where it used to be rare [125].

As IBD and IBS share key symptoms and are both commonly occurring, although IBS is by far the more frequent, gastroenterologists are often faced with the diagnostic challenge of differentiating patients with IBD from those with IBS. Due to the symptom overlap it can be difficult to distinguish between the two based on anamnesis and clinical assessment alone [126]. Differential diagnosis, although broad [127], is essential and of great importance to the direction of further diagnostic interventions, medication, and prognosis. Prompt diagnosis is vital in facilitating early initiation of treatment, especially in children and adolescents, to prevent adverse effects such as delayed onset of puberty, impaired growth, and unnecessary suffering [128].

Treatmentwise, and for prognostic reasons, it is thus essential to successfully distinguish the organic from the functional gastrointestinal diseases. The gold standard for diagnosing IBD is endoscopy, primarily colonoscopy, with histological assessment of biopsy specimens [129]. As there is no single pathgnomonic symptom for either IBD or IBS, many IBS patients are also, unnecessarily, investigated extensively with invasive imaging techniques such as endoscopy to reach a diagnosis of exclusion. Endoscopy is not only invasive, but also resource intensive, requires patient preparations [130], and is associated with the inherent risks of such invasive procedures [131], as well as a hesitancy of patients to undergo them [132]. Endoscopies are thus not suitable for frequent use, especially not in children, where general anesthesia is often required. There is consequently a need for a non-invasive, simple, and cheap test that could provide objective evidence of whether the underlying disease is organic or functional. A test that will effectively rule out IBD, which requires further investigations, could aid clinicians in deciding which invasive investigations to request or possibly to avoid in cases in which the diagnosis indicated is IBS. The most striking difference between IBD and IBS is that the former is inflammatory in nature. Thus, one possibility to differentiate between the two would be to measure surrogate markers of intestinal inflammation.

## Calprotectin

Calprotectin was first described by Fagerhol *et al.* in 1980 [133]. This protein, earlier referred to as L1 [134], MRP-8/14 or S100A8/S100A9 [135, 136], calgranulin [137], and cystic fibrosis antigen [138], has a molecular mass of 36.5 kDa and consists of two heavy and one light chain [139]. It is a calcium- [136] and zinc-binding [140] phagocyte-specific S100 protein [141], which comprises about 60% of the cytosolic protein contents of neutrophil granulocytes [142]. Each granulocyte contains 2–5 pg calprotectin per cell [139], comparative to the amount of hemoglobin in one erythrocyte [143].

Calprotectin is released from the neutrophils when they are activated and the protein concentration in feces can rise to over 100 times the normal level in connection with for example IBD [144]. Estimation of calprotectin is advocated for early assessment in patients who present with symptoms suggestive of IBD. Patients with active IBD will have markedly elevated levels of fecal calprotectin, whereas patients with IBS will have normal levels [145, 146]. The cut-offs most commonly used clinically when distinguishing IBD from other gastrointestinal diagnoses is 50 µg/g feces and 100 µg/g feces, respectively. Initially a higher diagnostic precision in distinguishing IBD from non-IBD diagnoses was demonstrated for a cut-off of 100 µg/g [147], but recently the use of a cut-off of 50 µg/g has been suggested [148, 149].

Lately, calprotectin has been recognized as a promising marker of neutrophilic intestinal inflammation, which, when measured in feces, has a good overall diagnostic precision in discriminating IBD from non-IBD diagnoses, *e.g.* IBS, and is equally good in children and adults [150-154]. F-calprotectin also has potential in treatment follow-up, monitoring of disease activity, and as a prognostic marker for relapse in patients with known IBD who are in remission: situations in which evaluation of F-calprotectin levels has demonstrated promising results as an investigative method alternative to endoscopy [155-164].

# Aims

The utilization of laboratory tests increases steadily, and consequently also the costs associated with such testing. Many of the tests ordered are, however, deemed unnecessary, and, as the demands to lower the costs of care rise, the need for information about test usage increases.

The overall aim of this thesis was to study the use of laboratory tests in Sweden with the objective to evaluate and optimize laboratory test utilization. Considering the importance of laboratory analyses in modern health care, it is of utmost importance to increase the understanding of the usage of such tests. Efficient test utilization is a major part of cost-efficient, high-quality health care. In more detail, the aims of the individual papers were as follows:

## Paper I

To study the long-term effects of continuing medical education on the utilization of a number of clinical chemistry laboratory analyses to determine the permanence of educational effects on test ordering behavior.

## Paper II

To determine the extent of regional variations in test utilization and the influence of factors earlier described as explanatory, as well as to calculate the achievable cost savings associated with optimized test ordering.

## Paper III

To assess the cost-effectiveness of using F-calprotectin as a first-line screening test to minimize unnecessary invasive procedures and set direction for the overall diagnostic approach for IBD.

## Paper IV

To describe and evaluate longitudinal trends in costs, charges, and test utilization at the Clinical Chemistry and Pharmacology Laboratory at Akademiska sjukhuset, a large tertiary care university hospital in Uppsala, Sweden.

# Materials

The data used in the studies included in this thesis were retrieved from the following sources:

## The Laboratory Information System of the Clinical Chemistry and Pharmacology Laboratory at Akademiska sjukhuset (Papers I–IV)

In Paper I, the test orders of the included primary health care physicians were monitored by production statistics obtained from the Laboratory Information System (LIS). The test orders of 2004 for 23 general practitioners at 16 primary health care centers that participated in the initial continuing education as well as the ones placed by the same physicians in 1997 were retrieved.

In Paper II, data on all tests ordered by the primary health care centers in the county of Uppsala in 2004 were retrieved.

In Paper III, data on the initial F-calprotectin test results of 3 639 patients at Akademiska sjukhuset performed during 2008 were extracted from the LIS of the Clinical Chemistry and Pharmacology Laboratory.

In Paper IV, data on all test results generated at the Clinical Chemistry and Pharmacology Laboratory from January 1 2002 through December 31 2008 were retrospectively extracted.

## The Laboratory Information Systems in the studied counties, excluding Uppsala (Paper II)

Variations in the use of 16 clinical chemistry tests were evaluated for 223 primary health care centers in eight counties in Sweden using test request data. Representatives in the respective counties were contacted and asked to provide data on all the test orders made by physicians at all primary health care centers in their county.

## Annual reports (Paper IV)

Demographic data as well as data on institutional characterization of Akademiska sjukhuset and of the Clinical Chemistry and Pharmacology Laboratory, respectively, were extracted from the annual reports of 2002 and 2008 of Akademiska sjukhuset as well as of the Academic Laboratory, of which the Clinical Chemistry and Pharmacology Laboratory is one of the six sub-units.

## Sjukvårdsdata i fokus (Papers II and IV)

Information and statistics on the number of consultations with a primary health care physician per year, as well as per inhabitant per year, along with data on physician density, and the total net costs of health care in Sweden, were retrieved from the online database 'Sjukvårdsdata i fokus' [Health care data in focus] provided by the Swedish Association of Local Authorities and Regions (Sveriges Kommuner och Landsting).

## Statistics Sweden (Papers II–IV)

Data on changes in CPI and GDP, the age distribution of the population in the studied counties, the number of inhabitants in the Swedish counties, as well as the country as a whole, were retrieved from the online 'Statistics database' provided by Statistics Sweden (Statistiska centralbyrån).

## Swedish National Rural Development Agency (Paper II)

Data on the percentage of the population in each county living in rural areas were retrieved from the statistics database of the Swedish National Rural Development Agency (Glesbygdsverket).

## The official fee schedules of Akademiska sjukhuset (Papers II–IV)

The charges for laboratory tests and colonoscopies were retrieved from the respective official fee schedules of Akademiska sjukhuset.

# Methods

Statistical analyses were performed using SAS 9.1 software, StatSoft Statistica 8.0 statistical software, or Microsoft Excel 2003. The statistical methods used in this thesis include the following:

## Sign Test (Paper I)

Due to sample size and the data not being normally distributed, a non-parametric test was most suitable for the statistical calculations performed in Paper I. Sign Test, a non-parametric alternative to the paired *t*-test to compare two sets of results for the same samples, was used for all comparisons of differences in ratios between 1997 and 2004 evaluated in Paper I. The level of significance was set to 5% for each test. Calculations were made using StatSoft Statistica 8.0 statistical software.

## Kruskal–Wallis test (Paper II)

The Kruskal–Wallis test was used for the between-group comparisons when assessing the extent of differences in practice between the investigated counties regarding the laboratory test utilization, as judged by the median test ratios. Kruskal–Wallis is the non-parametric equivalent of the parametric one-way ANOVA. It is applied to the comparison of the medians of three or more unmatched samples that need not have the same number of measurements. These calculations were performed using SAS 9.1 software.

## Bootstrap (Paper II)

The 95% confidence interval for the median of each of the 13 investigated ratios was calculated for each county using a bootstrap procedure with 10 000 replications. The bootstrapping method allows an estimate of the distribution of the statistic to be made through establishment of a number of hypothetical datasets. The random sampling was performed with replacement, meaning that some ratios will be included in the sample multiple times, whereas other ratios might not appear at all. These statistical analyses were performed using SAS 9.1 software.

## Spearman's Rank Correlation Coefficient (Paper II)

When investigating if variables earlier described in the literature as explanatory of variations in test ordering were correlated to the inter-county variations in test ordering seen in Paper II, the non-parametric Spearman Rank Correlation Coefficients were calculated for the evaluated factors using StatSoft Statistica 8.0 statistical software.

## Cost-minimization analysis (Paper III)

In cost-minimization analysis (CMA) input costs are measured and compared, and outcomes are assumed to be equivalent. CMA can be used to determine the least costly option for a specific situation, such as in Paper III, the least costly method in the diagnostic work-up of IBD. The CMA was performed using Microsoft Excel 2003.

# Results and Discussion

## Paper I. Long-term effects of an education programme on the optimal use of clinical chemistry testing in primary health care

CME, a widely used method to promote rational test utilization, has often been reported to have an initial positive effect, although this effect has occasionally been shown to decline once the intervention is concluded [31, 74]. However, as most studies on the effects of CME have been short, long-term data are lacking [64]. The objective of this study was to determine the long-term effects of a short audit CME intervention that had displayed positive short-term influence on laboratory test utilization [165].

The educational effects were monitored using ratios of laboratory tests. Maintained or improved ratios were interpreted as a sustained educational impact. 92% of the studied ratios had remained at the same level or improved further since the short-term follow-up, suggesting long-term educational effects. Table 2 and Table 3 display the changes in medians between 1997 and 2004 for the ratios investigated.

Table 2. Ratios that were expected to have remained the same or to have decreased.

| Ratio | Median 1997 | Median 2004 | Difference 2004–1997 | Interquartile range | p value of difference 2004–1997 |
|---|---|---|---|---|---|
| AST/ALT | 0.057 | 0.031 | −0.026 | 0.302 | ns |
| Bilirubin/ALP | 0.250 | 0.139 | −0.111 | 0.485 | ns |
| Cholesterol/HDL-cholesterol | 1.000 | 1.217 | 0.217 | 1.129 | ns |
| Cholesterol/all tests | 0.026 | 0.058 | 0.032 | 0.076 | ns |
| Sodium/potassium | 0.032 | 0.075 | 0.043 | 0.144 | ns |
| T3/TSH | 0.029 | 0.022 | −0.009 | 0.091 | ns |
| T4+fT4/TSH | 0.273 | 0.237 | −0.036 | 0.174 | ns |

ns = not significant.

As attitudes toward an intervention highly predict behavioral intention [166, 167], we sought to evaluate the participants' attitudes towards the educational intervention and the contents of it. Our CME aimed to bring about changes in test ordering by creating an understanding of why optimization was necessary and what improvements the altered test ordering behavior would convey. The education was designed to use scientifically supported recommendations regarding test utilization to convince the participants of the benefits of changing their test ordering pattern rather than forcing change by economic means of control. Thus, in addition to the evaluation of changes in the participants' test ratios over time, a short questionnaire was used to investigate the physicians' attitudes toward the contents of the course and the perceived importance of similar educational efforts. The absolute majority stated that they regarded the information given in the course as being very useful in performing their daily work, and the general opinion conveyed that continuous implementation of the education should be pursued. The fact that the physicians have such positive attitudes toward the continuing education and the knowledge acquired during the course is very important, as "neither doctors nor other personnel can be expected to respond favorably to change with which they do not agree" [165].

The results suggest that CME can bring about long-lasting changes in test ordering. CME is thus a suitable means of improving quality and cost-efficiency in test utilization.

Table 3. Ratios that were expected to have remained the same or to have increased.

| Ratio | Median 1997 | Median 2004 | Difference 2004–1997 | Interquartile range | p value of difference 2004–1997 |
|---|---|---|---|---|---|
| Calcium/all tests | 0.000 | 0.019 | 0.019 | 0.017 | <0.05 |
| Methylmalonate/ all tests | 0.000 | 0.001 | 0.001 | 0.004 | ns |
| Ferritin/all tests | 0.011 | 0.006 | −0.005 | 0.010 | ns |
| TSH/all tests | 0.115 | 0.072 | −0.043 | 0.169 | <0.05 |
| Triglycerides/ cholesterol | 0.842 | 0.813 | −0.029 | 0.533 | ns |

ns = not significant.

## Paper II. Costly regional variations in primary health care test utilization in Sweden

Variations in clinical practice have been demonstrated to be an important determinant of expenditure for laboratory tests in primary physician services [51]. The responsibility for cost control and proper use of laboratory investigations has been argued to be particularly important for primary health care physicians who often are the first to see and assess patients and thus determine the initial number of tests to be ordered [21]. In this study we therefore determined and evaluated the variations in test utilization in primary health care. For all ratios investigated, there were significant inter-county differences (see *Figure 5* and *Figure 6*) yet, separately, none of the demographic variables investigated were able to explain the variations, see Table 4. The inter-county differences in test utilization are likely influenced by over- as well as under- and misutilization in combination with local traditions and habits.

Table 4. The investigated variables and their respective Spearman Rank Correlation Coefficients.

| County | Tests/1 000[a] inhabitants | % ≥65 years[b] | % in rural areas[c] | Consultations per year[d] | Physician density[e] |
|---|---|---|---|---|---|
| Dalarna | 1 788 | 19.9 | 3.7 | 1.25 | 0.5 |
| Gävleborg | 2 030 | 20.0 | 1.4 | 1.36 | 0.6 |
| Halland | 1 743 | 17.9 | 0.002 | 1.52 | 0.6 |
| Jämtland | 4 452 | 19.9 | 29.4 | 1.37 | 0.6 |
| Kalmar | 3 348 | 20.6 | 0.99 | 1.33 | 0.6 |
| Sörmland | 2 325 | 18.7 | 0.03 | 1.26 | 0.5 |
| Uppsala | 1 853 | 14.6 | 0.31 | 1.10 | 0.6 |
| Östergötland | 2 019 | 17.8 | 0.19 | 1.05 | 0.5 |
| $r_s^f$ | | 0.527 | 0.429 | 0.167 | |

[a]The number of clinical chemistry tests ordered per 1 000 inhabitants, [b]The percentage of the population aged ≥65 years [167], [c]The percentage of the population living in rural areas [168], [d]The mean number of consultations with a primary health care physician per inhabitant per year [169], [e]The physician density per 1 000 inhabitants [169], [f]The Spearman Rank Correlation Coefficient for correlations between the number of ordered tests per 1 000 inhabitants and the respective variables.

The estimated total savings achievable over a period of one year per 100 000 inhabitants ranged from €13 920 to €184 598, see Table 5. The median savings associated with optimized utilization of the tests in group A outweighed the median costs incurred by optimized usage of the group B tests by about 10%.

Table 5. Achievable cost savings.

| | Highest median ratio[a] | Second lowest median ratio[a] | Lowest median ratio[a] | Cost per numerator test | Range of yearly savings/ 1 000 inhabitants[b] |
|---|---|---|---|---|---|
| AST/ALT | 0.998 | 0.107 | 0.002 | €4.1 | €505–58 682 |
| Bilirubin/ALP | 1.000 | 0.325 | 0.314 | €1.6 | €95–15 402 |
| Cholesterol/ HDL-cholesterol | 1.454 | 1.023 | 1.013 | €2.1 | €116–5 391 |
| Cholesterol/ all tests | 0.047 | 0.022 | 0.018 | €2.1 | €3 740–10 888 |
| Sodium/potassium | 0.994 | 0.187 | 0.057 | €1.6 | €1 788–30 858 |
| f-T3/TSH | 0.267 | 0.056 | 0.028 | €8.8 | €1 869–21 664 |
| f-T4/TSH | 0.995 | 0.426 | 0.344 | €5.7 | €5 818–41 713 |
| Total savings | | | | | €13 920–184 598 |

[a]Each of the highest, second lowest and lowest median ratios in group A are displayed irrespective of county origin to indicate achievable ranges of savings. [b]The range of total savings per 100 000 inhabitants that could be achieved through optimized test ordering is indicated in 2008 euros based on the official fee schedule of Akademiska sjukhuset for 2008.

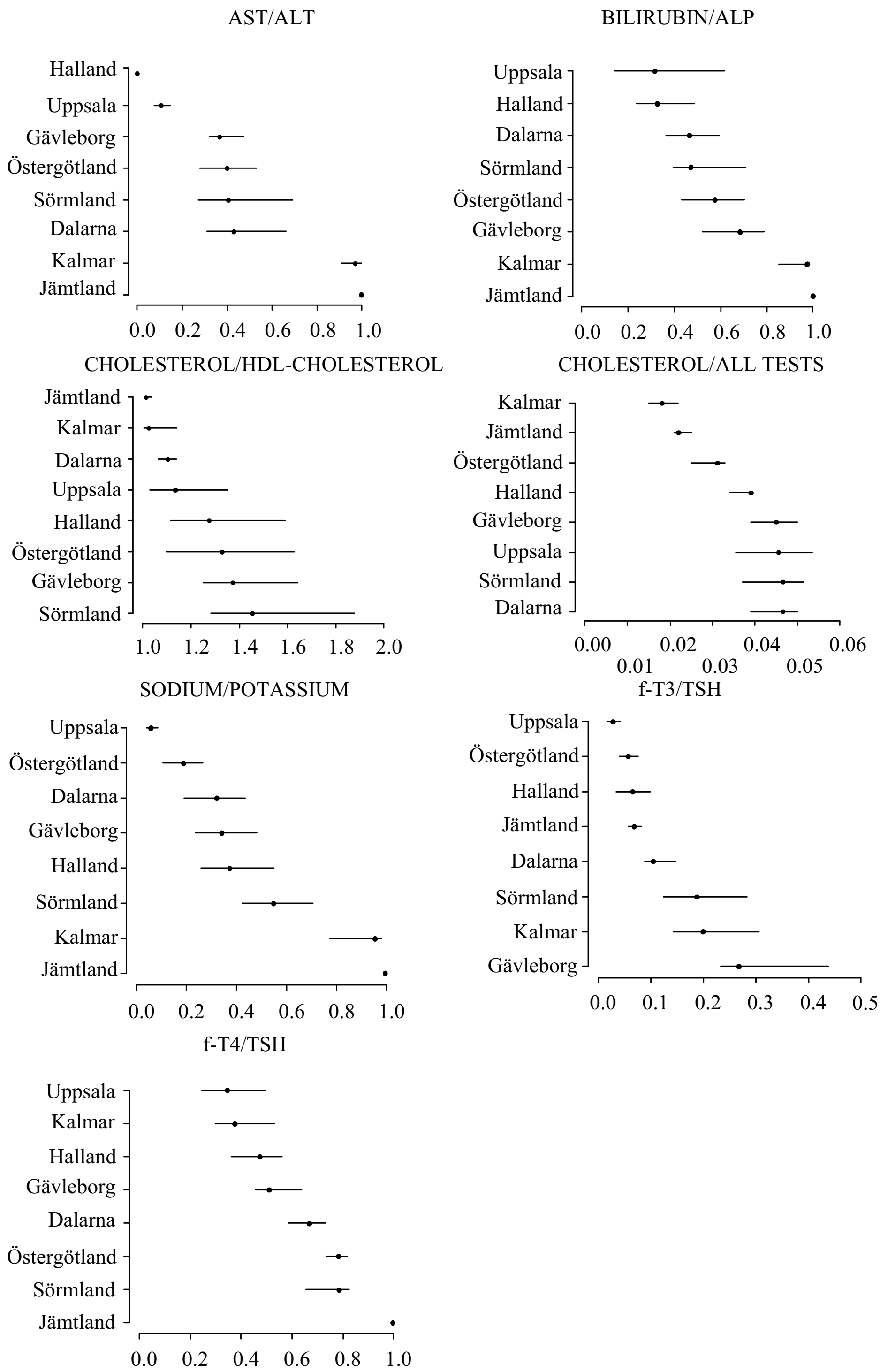


*Figure 5.* Group A ratios. The numerator analyses should be low in relation to the denominator analyses. The median ratios and their 95% confidence intervals are presented. The county with the lowest median ratio is displayed at the top.

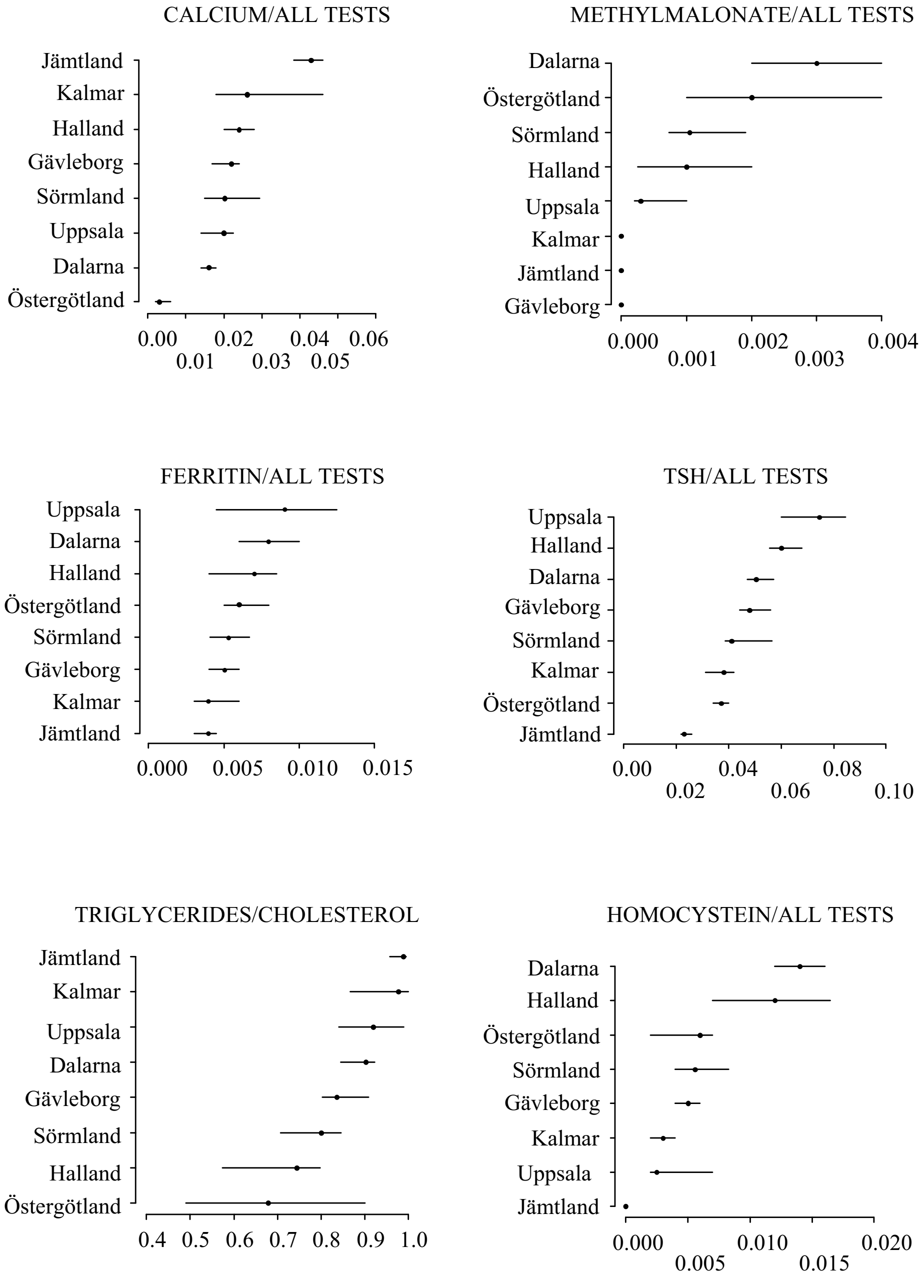


*Figure 6.* Group B ratios. The numerator analyses should be high in relation to the denominator analyses. The median ratios and their 95% confidence intervals are presented. The county with the highest median ratio is displayed at the top.

The study revealed large regional differences in test utilization in primary health care in Sweden, and it was established that the total yearly expenditures for laboratory tests could be substantially reduced. Even when the costs incurred by extended use of the group B tests were taken into account, the savings from optimized ordering of the group A tests still outbalanced the increased costs. Optimized utilization of laboratory tests will most certainly also have effects beyond the direct laboratory cost savings. As the number of ordered tests decrease, so will the risk of generating false positive test results that demand attention and follow-up. Such indirect effects may be just as important as the direct savings and their economic effects as great as or greater than the direct savings.

The considerable inter-county variations found here along with the estimative calculations of the savings associated with optimized test utilization indicate that large cost savings could be achieved alongside a quality improvement.

## Paper III. Ruling out IBD: the cost-effectiveness of pre-endoscopic screening with F-calprotectin

Differentiation of patients with IBD from patients with IBS poses a diagnostic challenge, and differential diagnosis based on clinical assessment alone is very difficult [126]. However, colonoscopy, the gold-standard for diagnosing IBD, has several drawbacks rendering it unsuitable for frequent use [130-132]. F-calprotectin, on the other hand, is a non-invasive, cheap test that is very useful in distinguishing IBD from IBS [121, 168]. In this study, the cost-effectiveness of using F-calprotectin tests to minimize unnecessary colonoscopies was estimated. For the outline of the sequential testing strategy evaluated, see *Figure 7*. The characteristics of the data set are presented in Table 6.

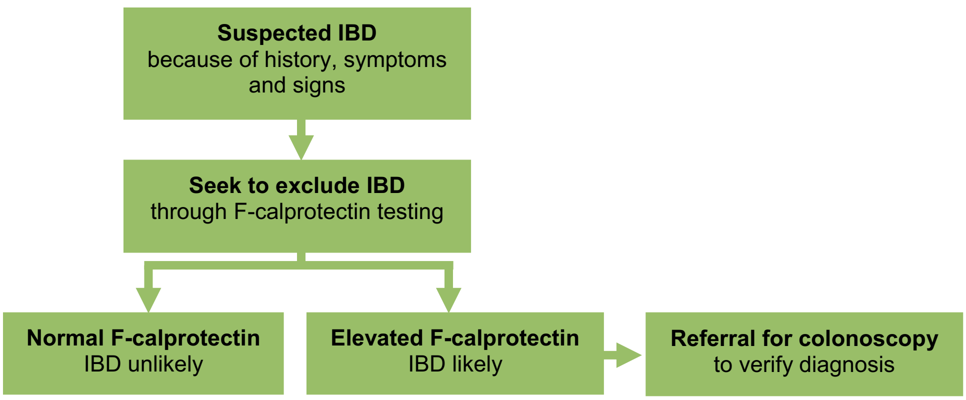


*Figure 7.* The outline of the sequential testing strategy.

Table 6. Characteristics of the data set.

| | All patients $n$ = 3 639 | F-calprotectin <50 µg/g, $n$ (%) | F-calprotectin <100 µg/g, $n$ (%) |
|---|---|---|---|
| Patient age, mean (min–max) | 36 (0–95) years | | |
| № of patients ≤18 years, *n* (%) | 1 206 (33.1%) | 653 (54.1%) | 855 (70.9%) |
| № of patients 18–65 years, *n* (%) | 2 085 (57.3%) | 1 079 (51.8%) | 1 419 (68.1%) |
| № of patients ≥65 years, *n* (%) | 474 (13.0%) | 140 (29.5%) | 240 (50.6%) |
| Male patients, *n* (%) | 1 453 (39.9%) | 713 (49.1%) | 937 (64.5%) |
| Female patients, *n* (%) | 2 186 (60.1%) | 1 098 (50.2%) | 1 498 (68.5%) |
| F-calprotectin, mean | 242.1 µg/g | | |
| F-calprotectin, min–max | 0–20 708 µg/g | | |

Pre-endoscopic F-calprotectin screening reduced the number of required colonoscopies by 49.7–66.9%. For more details on the distribution of patients in the testing strategy arms, see *Figure 8*. The cost avoidance, after deduction of the costs incurred by F-calprotectin screening, was 50.1–67.0%, corresponding to €1 569 989–2 131 669, depending on the cut-off used, see Table 7.

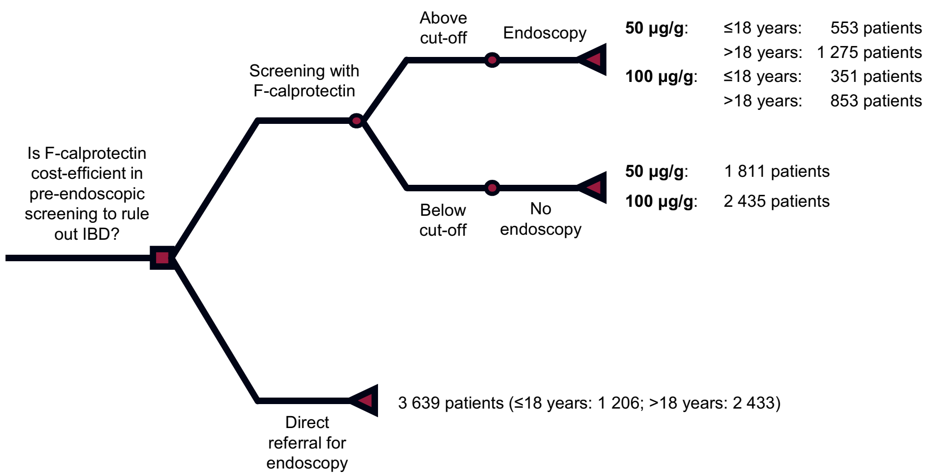


*Figure 8.* The distribution of patients in the sequential testing strategy applied when evaluating the use of F-calprotectin as a filter to minimize unnecessary colonoscopies by ruling out patients that most likely do not have IBD.

Almost twice as many tests were ordered for patients 10–19 years of age, than for patients in any other 10-year age span. These findings are in concordance with the large percentage of patients with IBD presenting before age 20 [169]. More women than men were investigated with an F-calprotectin test, yet the percentage of normal test results was higher for women, which was likely a reflection of the findings of previous studies that more women than men suffer from IBS [170].

Table 7. Total costs for the respective testing strategy arms.

| | Endoscopy | | F-calprotectin | Total costs |
|---|---|---|---|---|
| | № of patients ≤18 years | № of patients >18 years | № of patients | |
| Direct referral | 1 206 | 2 433 | 0 | €3 294 600 |
| Screening, 50 µg/g cut-off | 553 | 1 275 | 3 639 | €1 724 611 |
| Screening, 100 µg/g cut-off | 351 | 853 | 3 639 | €1 162 931 |

Assuming the test ordering and morbidity patterns in Uppsala to be representative of those in Sweden as a whole, a cost avoidance of approximately €17 million–23 million could be achieved, as compared to direct referral for colonoscopy for all patients.

The study demonstrated that the use of a pre-endoscopic F-calprotectin screening test would clearly be favorable, from a cost-effectiveness point of view, to direct referral for colonoscopy. In addition to the costs of the diagnostic investigation itself, several attendant costs are associated with endoscopy. If these additional costs were to be factored into the equation, the potential savings associated with F-calprotectin screening would be even greater.

## Paper IV. Longitudinal trends in laboratory test utilization at a large tertiary care university hospital in Sweden

The laboratories are often among the first disciplines to be targeted for budget reductions because their costs are easily discernable. However, as reduced test utilization produces disproportionately small true cost reductions [106], and test utilization is intimately related to other health care costs, it does not necessarily follow that a reduction in test utilization will lead to a decrease in the overall health care costs. Accurate and timely information on trends in test utilization is therefore essential to optimal financial management of clinical laboratories and hospitals.

The variables evaluated in this study and their inflation-values for 2002 and 2008, respectively, are presented in Table 8.

Table 8. Evaluated variables and their inflation-adjusted values.

| | 2002 | 2008 |
|---|---|---|
| Generated test results[a] | 3 760 508 | 6 402 617 |
| Analyses offered | 309 | 663 |
| Mean price charged per test[b] | €34.9 | €37.5 |
| Total laboratory expenditures | €10.4 million | €12.5 million |
| Testing expense[c] | €2.8 | €2.0 |
| Primary health care visits with a physician | 245 500 | 292 100 |
| Admissions | 53 504 | 58 001 |
| Outpatient visits with a physician | 291 000 | 419 213 |
| Additional outpatient visits | 329 000 | 419 213 |
| Total hospital expenditures | €513 million | €629 million |

[a]Includes non-chargeable test results such as calculations and ruined samples, [b]According to fee schedule, not volume adjusted, [c]Total laboratory expense/total number of generated test results.

From 2002 to 2008 the number of generated test results increased by over 70% with an average annual increase of 9.30%, see *Figure 9*.

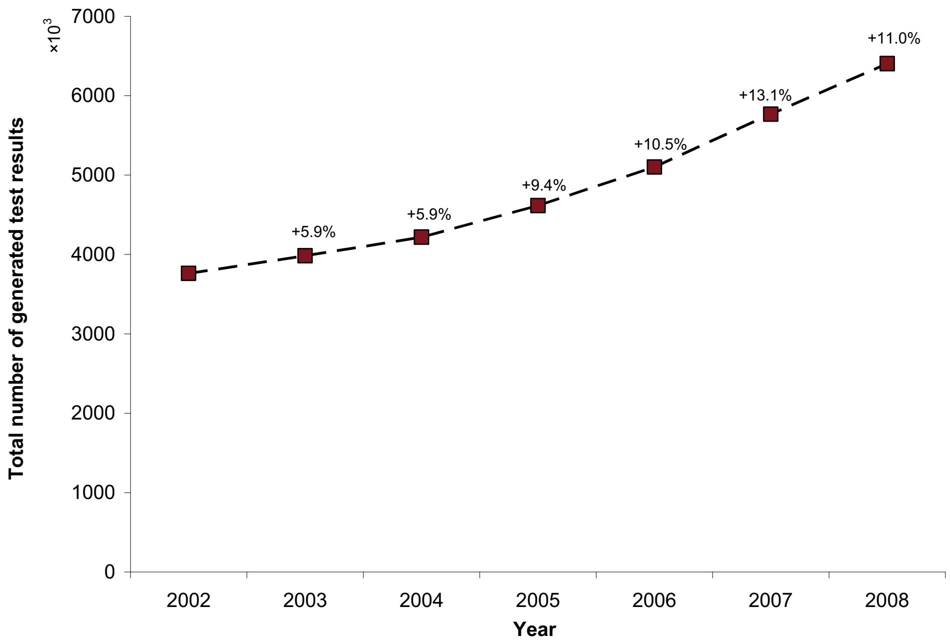


*Figure 9.* The increase over time in laboratory test utilization as defined by the number of generated test results.

The 10, 20, and 30 most commonly ordered tests represented, on average, 46.9%, 66.9%, and 75.5%, respectively, of the total number of generated test results during the studied period, see Table 9.

Unlike the mean price charged per test, the testing expense decreased during the studied period, most likely due to a combination of increased automation and efficiency. The number of different analyses offered more than doubled during the studied period. Even so, the share of the total number of generated test results that was represented by the 10 most commonly ordered analyses was very stable at approximately 50% throughout the studied period, indicating that most of the new additions to the test menu were low-frequency tests.

Table 9. Percentage of the total number of tests represented by the most commonly ordered tests.

| Year | Total number of ordered tests | 10 most commonly ordered tests | 20 most commonly ordered tests | 30 most commonly ordered tests |
|---|---|---|---|---|
| 2002 | 3 760 508 | 40.4% | 59.5% | 67.6% |
| 2003 | 3 983 149 | 47.7% | 69.7% | 78.7% |
| 2004 | 4 218 082 | 47.6% | 69.1% | 77.6% |
| 2005 | 4 614 524 | 48.8% | 69.3% | 77.1% |
| 2006 | 5 100 550 | 48.0% | 67.4% | 75.8% |
| 2007 | 5 766 947 | 47.9% | 66.7% | 76.2% |
| 2008 | 6 402 617 | 47.8% | 66.4% | 75.7% |
| Mean | 4 835 197 | 46.9% | 66.9% | 75.5% |

The principal findings of this study were substantial increases in the number of generated test results and in the number of tests offered, despite a virtually unchanged share of the hospital's total expenses represented by the costs of laboratory testing. The increase in patient throughput, as determined by the number of admissions, outpatient visits, and primary health care visits, could only explain less than one third of the increase in test utilization. The major part of the increase in test utilization is thus most likely due to intrinsic growth. The increase in workload in this study is in the range of average laboratory test growth rates reported in other countries during the period of 1970–2005 [20, 171-176]. The percentage of the total number of generated test results represented by the 30 most commonly ordered tests was similar to that reported in other studies [173, 175]. The data on the top-30 tests could be used as an indication of where small changes in test utilization may bring about considerable savings, as small technologies are likely to account for far more of the overutilization than big expensive technologies [98], and low-cost high-frequency tests have been demonstrated to account for the major proportion of laboratory costs [97].

Very little has thus far been published about changes in test utilization over time. This study provides insight into the utilization and economics of laboratory testing during a period that was characterized by tightened budget control and ever-growing concern about medical costs. The study defines trends and may thus have potential predictive values.

# Conclusions

- CME can bring about long-lasting changes in the test ordering habits of primary health care physicians.
- CME can be used as a means of improving the cost-efficiency as well as the quality of test utilization.
- There are large regional differences in test utilization in primary health care in Sweden.
- Considerable inter-county variations indicate that large cost savings could be achieved alongside a quality improvement.
- Inter-county differences in test utilization are likely to be influenced by over- as well as under- and misutilization due to local traditions and habits.
- The savings associated with optimized test utilization are considerable.
- F-calprotectin has the potential to substantially reduce the number of invasive investigations necessary in the diagnostic work-up of patients with suspected IBD.
- F-calprotectin screening could lead to a cost avoidance of €17–23 million annually in Sweden as compared to direct referral for colonoscopy.
- The total number of test results generated at the Clinical Chemistry and Pharmacology Laboratory at Akademiska sjukhuset in Uppsala has increased by over 70% in 6 years.
- Even though the selection of tests has more than doubled, a very small number of tests account for a stable, and disproportionally large, share of the total number of generated test results.
- Despite the substantial increase in the number of generated test results, the laboratory's share of the hospital's total expenditures has remained virtually unchanged.