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The Finnish experience to save asthma costs by improving care in 1987 - 2013

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Abstract

The Finnish national asthma program 1994-2004 markedly improved asthma care in 1990s. We evaluated the changes in costs during 26 years, from 1987 to 2013. Direct and indirect costs were calculated using data from national registries. Costs from both societal and patient perspective were included. The costs were based on patients with persistent, physician-diagnosed asthma verified by lung function measurements. We constructed minimum and maximum scenarios to assess the impact of improved asthma care on total costs. The number of patients with persistent asthma in national drug reimbursement register increased from 83 000 to 247 583. Improved asthma control reduced health care use and disability resulting in major cost savings. Despite a threefold increase in patients, the total costs decreased by 14 %, from € 222 to 191 million. Costs for medication and primary care visits increased but overall annual costs per patient decreased by 72 %, from € 2 656 to 749. The theoretical total cost savings for year 2013 – comparing actual costs to predicted – were between € 120–475 million depending on the scenario used. The Finnish asthma program resulted in significant cost savings both at societal and patient level during a 26-year period.

Abstract word count 197

49 Introduction

50 In most countries the total costs of asthma treatment have gradually increased due to increased
51 asthma prevalence and rapidly growing costs of newer drugs (1). In Finland, the prevalence of
52 asthma in adults was approximately 6 % in 1990s (2, 3) but has increased since then. In Helsinki
53 capital area, population based surveys indicated a prevalence of physician diagnosed asthma of
54 6.8 % in 1996 and 9.4 % in 2007 (4). In adults aged 25-64 years, the age-adjusted prevalence of
55 physician-diagnosed asthma increased from 6.1 % to 9.5 % in men and from 7.8 % to 10.8 % in
56 women from 1997 to 2012 (5).

57
58 In 2013, the Finnish Social Insurance Institution (SII) listed 247,583 patients with physician-
59 diagnosed asthma who were entitled to special reimbursement for drug costs due to their need for
60 maintenance medication for persistent disease. This number was three times larger than the
61 equivalent in 1987. The population of Finland has increased from 4 938 602 to 5 451 270 (10 %)
62 during the same period.

63
64 Significant advances in asthma care, especially in diagnostics and pharmacotherapy, have taken
65 place since 1987. The main changes in pharmacotherapy have been the use of regular inhaled
66 corticosteroids (ICS) as first-line therapy in all asthma patients (6, 7) and secondly the introduction
67 of new drugs such as inhaled long-acting β_2 -agonists (LABA), combinations of LABA and ICS and
68 leukotriene receptor antagonists.

69
70 A 10-year national asthma program was established in Finland from 1994 to 2004 to lessen the
71 burden of disease (8, **Box 1**). As a result, the overall asthma care improved, patients obtained a
72 better disease control and costs decreased (9, 10). These changes were achieved via systematic
73 planning, education and networking to implement early detection and anti-inflammatory

74 treatment (mainly ICS) at all levels of asthma care. The local efforts improved co-operation
75 between primary and secondary health care providers.

76 Encouraged by the good results, a new national allergy program 2008-2018 was launched to take
77 further steps to reduce the burden of all allergic conditions, including asthma (11).

78 We have evaluated whether the systematic approach to improve asthma management in Finland
79 has resulted in long-term cost savings. We used Finnish registry data from different sources for
80 appraisal of the effectiveness of asthma care interventions during the 26-year period from 1987
81 to 2013. Comprehensive time-series analysis allowed detection of trends in costs and
82 identification of relevant cost-drivers.

83 **Data and Methods**

84

85 The cost of illness calculations included the direct cost of care (outpatient visits, hospitalisations,
86 medication) as well as indirect costs i.e. sickness allowances and disability pensions. The data on
87 both direct and indirect costs were based on national registries (**Suppl. Table**). The number of
88 asthma patients was based on the Finnish Social Insurance Institution's (SII) registry. This
89 registry includes all patients in Finland with persistent asthma entitled to special reimbursement
90 for asthma drugs. The number of patients included in the SII registry is an underestimation of the
91 true prevalence of asthma, because patients are not registered if they only have intermittent or
92 mild disease not needing regular medication. However, the SII registry reliably reflects the
93 number of patients with a persistent disease and can be used for comparison throughout the
94 observation period. The diagnostic and reimbursement criteria have been validated and remained
95 essentially the same (12). The Finnish asthma reimbursement code (203) identifies patients with
96 significant asthma with great accuracy, because the diagnosis must be verified by objective lung

function measurements (13). The patients must also need regular medication, as judged and documented by their physicians.

Health care use and direct costs

All secondary care outpatient visits, emergency care, and hospital admissions where asthma was the primary diagnosis in 1987-2013 were collected from national discharge registries maintained by the National Institute for Health and Welfare. During the observation period primary care visits were not registered in Finland and not included in the calculations. Instead, we estimated primary care visits using the benchmarking database on asthma care in 10 Finnish cities in 2013 by the Nordic Healthcare Group (NHG), and the prevalence of asthma. The national registry also is silent on visits to private healthcare providers. Moreover, benefits paid by the private insurance companies were not available. However, private sector services have a negligible role in inpatient care while they accounts for about 25 % of the number of outpatient visits (mostly occupational care visits) as estimated by the NHG benchmarking.

The cost estimates were based on average unit costs of an outpatient visit (general practitioner or specialist) and inpatient hospital days in Finland in 2001 (14). All unit costs for other years were estimated using the healthcare cost index available from Statistics Finland (15). Finally, the annual nominal costs were converted to 2013 prices by using the general price level index.

The costs of medication were obtained from the annual statistics of the SII, which records the cost of medication bought by patients eligible for special reimbursement due to asthma. For patients with intermittent or mild asthma, not included in the SII registry, medication costs were not available. Annual medication costs were also converted to 2013 price level.

119 *Indirect costs (lost productivity)*

120 The study included transfer benefits, i.e. sick-leave compensations and disability pensions
121 caused by asthma, as indirect costs and for calculation of lost productivity (16). Sick leave data
122 were obtained from the SII statistical yearbooks for 1989-2013; data for 1987 and 1988 were
123 extrapolated with Constant Average Growth Rate (CAGR) as they were not available in the
124 yearbooks. This estimate does not include the shorter, non-compensated sickness leaves (less
125 than 9 days). Data on disability pensions due to asthma were obtained from the SII statistical
126 yearbooks for 1987-2013 and from the Finnish Centre for Pensions registries (2003-2013). The
127 cost of lost productivity was based on the number of sick leave days and pension days. The
128 average monthly income of the working age population was obtained from Statistics Finland.
129 Intangible elements such as decreased working capacity at workplace, value of lost life years due
130 to premature death and patients' quality of life (17) could not be included in the analysis as no
131 data were available.

132 *Cost scenarios*

133 We constructed "what if" scenarios to detect the important cost drivers for asthma care during
134 the study period. The actual (realized) annual expenditures of asthma care were compared with
135 the minimum (min) and maximum (max) scenarios of theoretical annual costs.

136 In the min scenario we assumed that in patients already in the register in 1987 the numbers of
137 hospital days, sick leave days and disability pensions would decrease from that year onwards
138 according to the general trends in Finland (18). Then, we assumed that the three-fold increase in
139 prevalence, as reflected by the Finnish Social Insurance Institution's (SII) registry, would be due
140 to milder cases of the disease and therefore would not have an increasing effect on
141 hospitalisations, sick leaves and disability pensions. Thus, in the min scenario the new "mild"
142 patients would only increase the medication cost.

In the max scenario we assumed that the prevalence of asthma increased, but the disease severity and care practices remained at the 1987 level. Thus, the number of hospital and sick leave days and disability pensions would decrease according to the general trend, but the increasing number of patients would result in an increase of absolute numbers.

The differences between the observed actual costs and the min and max scenarios would indicate the range of the theoretical savings due to improved care.

Results

Patients

Table 1 characterizes Finnish persistent asthma prevalence according to age and gender at the beginning, middle and end of the study period. In 1987, there were 83 000 asthma patients (1, 6 % of the entire population) entitled to special reimbursement for drug costs. By 2013, the number had increased to 247 583 (4, 6 %). The increase reflects mainly improved diagnostics and treatment coverage. The age profile of patients changed somewhat during the study period. The percentage of working age asthmatics (16 to 64 years) declined from 63 % to 55 % while the share of those aged 65 years or older increased from 27 % to 38 % (18).

Changes in health care use, disability and mortality

The number of hospital days in secondary care decreased from 91 650 in 1987 to 12 050 in 2013 (86 %) and in primary care from 45 300 to 13 300 (71 %). In secondary care, the decrease in hospital days per patient per year was 95 % (from 1.10 to 0.05 days), and in primary care 90 % (from 0.54 to 0.05 days). There was a shift of outpatient visits from secondary to primary care as secondary care visits decreased by 38 % in total (79 % per patient, from 1.64 to 0.34 visits), while primary care visits increased by 98 % in total. Sick leave days decreased by 70 % in total,

167 89 % per patient, from 2.44 to 0.24 days). Disability pensions decreased by 79 % in total (93 %
168 per patient, from 0.08 to 0.01 pensioners). In 1987 6340 patients and in 2013 1310 patients had
169 disability pension because of asthma.

170 There was also a 57 % decrease in in age-adjusted asthma-related death rates from 3.5 to 1.5 per
171 100,000 per year. In 1987 there were 163 deaths due to asthma of which 11 were patients under
172 45 years of age. In 2013 the total number was 82 and only one was under the age of 45 years.

173 *Costs at societal level*

174 Although there was a threefold increase between 1987 and 2013 in the number of people with
175 persistent asthma (prescribed regular maintenance medication) total annual expenditure on
176 asthma care decreased by 14 % (from € 222 to 191 million) during the same period (**Fig. 1**). The
177 overall costs in the beginning and at the end of the study period are shown in **Table 2**, divided
178 into direct and indirect costs.

179 Direct healthcare costs associated with asthma increased by 50 % from € 90 million in 1987 to
180 135 million in 2013. In the cost component analysis, the costs of hospitalisations decreased by
181 73 %, from € 30 to 8 million. The costs due to secondary care outpatient visits remained the
182 same at € 24 million per year, but the costs of outpatient drugs increased by 187 %, from € 33 to
183 98 million. The costs due to primary care outpatient visits increased by 378 %, from € 1,1 to 5,5
184 million.

185 Lost productivity measured as sickness allowances and disability pensions decreased
186 significantly during the same period, by 58 %, from € 131 to 55 million. Sickness benefits
187 represented constantly approximately 10 % of these expenditures.

188 The most important single cost component at the beginning of the study period was lost
189 productivity, but this changed to direct health care costs by 1994.

Costs at patient level

In 2013 247 583 patients were eligible for special reimbursement of their drug costs and were used for assessment. Between 1987 and 2013, the overall annual costs per patient decreased by 71 %, from € 2670 to 771 (**Table 2, Fig. 2**). Direct health care costs, including medication expenses, decreased by 55 % (from € 1081 to 545 per patient). Costs of outpatient drugs decreased by 4 % (from € 409 to 394 per patient). Lost productivity dwindled by 86 % (from € 1589 to 226 per patient) during the 26 year period.

Cost scenarios

Fig. 3 shows the actual (realized) annual expenditures for asthma care in Finland and the min and max scenarios of theoretical development of annual costs. The change in service use and indirect costs in the scenarios are based on the general trends in health care in Finland (18). All hospital (inpatient) days in secondary care (whole population) decreased by 58 % and in primary care by 35 % from 1987 to 2013. Concomitantly, all secondary care outpatient visits (whole population) increased by 64 % and disability pensions (working age population) decreased by 34 %. The decreases for asthma patients were larger than these general trends resulting in estimated cost savings between € 120 (min) – 475 (max) million at the end of the observation period.

Discussion

A systematic data base search of the English literature from 1996 to 2008 showed that the costs of asthma are enormous (19) and despite effective therapies, these costs are increasing (20, 21). Improved asthma care ought to lessen the burden of disease on both the societal and individual patient's level. This has happened in Finland, where asthma detection and control was improved. At the start of the Finnish asthma program in 1994 it was estimated that 20 % of the patients had severe (or uncontrolled) disease (8). This figure decreased to 10 % in 2001 and 4 % in 2010 (22).

214 This led to a significant decrease in health care service usage, sickness leaves and disability
215 pensions. Although medication costs increased due to increased number of patients and higher
216 cost of new drugs, it did not come anywhere close to offset the major cost savings derived from
217 better disease control.

218 During a 26-year period the total annual societal costs of asthma diminished by 14 %, from
219 € 222 to 191 million while the number of patients on maintenance medication, registered by the
220 Finnish Social Insurance Institution, tripled. This increase in the number of patients reflects
221 mainly better awareness and detection of disease as well as coverage of effective treatment.
222 These factors may also have resulted in milder cases entering into the register. The criteria for
223 special reimbursement for drug costs have not, however, changed during the study period. The
224 cost decrease was remarkable at the patient level as well.

225 Cost savings were detected in all relevant paying sectors of the society. In particular, reductions
226 in sickness allowance days and disability pensions resulted in saved societal costs. An exception
227 was the increase in outpatient drug costs with the greatest relative growth at the latter half of the
228 1990's. This development was not surprising as the number of patients getting early diagnosis
229 and effective medication increased.

230 The clinical efficacy of ICS was shown already in early 1970s, but generally the drug was used
231 with small doses and not first-line (23). New pathophysiological knowledge about asthma
232 primarily as an inflammatory disease started to evolve from the mid 80's (24-26). Early and
233 precise diagnosis, with the help of effective lung function measurements, was emphasized and
234 anti-inflammatory medication with ICS was introduced as first-line. The greatest benefit for the
235 society was attained in the 1990s, when this strategy became widespread, and before the launch
236 of fixed combinations of ICS and LABA in 1999-2001. Altogether, since 2000, the use of ICS
237 has increased only marginally (see **Fig 3**).

238 One essential key for better patient care was improving treatment adherence by *guided* self-
239 management. In 1998 it was confirmed that educating patients to prevent asthma
240 exacerbations/attacks proactively was cost effective compared with traditional treatment (27).
241 The result was repeated in subsequent studies although at first intense education process was
242 costly (28).

243 The cost effectiveness of the newer therapies cannot be reliably assessed by a societal cost
244 analysis, as the evaluation would need knowledge on individual or cohort levels' quality of life
245 for calculation of quality-adjusted life-years (QALYs). Nevertheless, it is obvious that earlier
246 and more effective use of the older, relatively cheap drugs made a real change for the better and
247 yielded population level benefits. This approach could also be applied in developing countries
248 without jeopardizing their economies, thereby avoiding the substantial costs of emergency visits
249 and hospitalisations.

250 The Finnish asthma program 1994-2004, supported by the Ministry of Health and Social Affairs,
251 translated the new knowledge rapidly and consistently into clinical practice (8). An
252 implementation plan was outlined with strategic choices, defined goals and measures as well as
253 activities e.g. for capacity building and funding. Information, education, and effective
254 networking with different stakeholders were the primary keys. Patients were taken into the
255 program as active partners, mainly through non-governmental patient organizations. Co-
256 operation between asthma specialists, primary care physicians, nurses, pharmacists and the
257 pharmaceutical industry – the last mentioned as producers of approved information material –
258 resulted in rapid implementation of a program which could be achieved at low costs. A
259 motivating factor was that many of the studies contributing to the new understanding of asthma
260 originated from Finnish investigators in the international context (e.g. 29, 30).

261 Improved asthma care in Finland is an example of how nationwide implementation of a
262 successful strategy can decrease overall costs, despite increased numbers of patients needing
263 treatment. Focused asthma programs have also been effective in other countries, with associated
264 gains in QALYs (31,32) and improvements in quality of life, asthma symptoms and lung
265 function at lower direct costs compared with usual care (33, 34). Several European and other
266 countries have similar experiences as Finland (35-38). A group of experts, the Advancing
267 Asthma Care Network discussed asthma projects and programs in Argentina, Australia, Brazil,
268 China, Japan, Mexico, Philippines, Russia, South-Africa and Turkey (39). The group concluded
269 that the major barriers for successful programs are: 1) low rates of dissemination and
270 implementation of treatment guidelines, 2) low levels of continuing medical education and
271 training of primary health care professionals, and 3) access and distribution of ICS. In the less
272 developed asthma programs, under-recognition and under-treatment further limited the success.

273 The Finnish financial system for providing care for chronic diseases such as asthma is
274 complicated, as it is in most EU countries, and divided into several sectors. The division of
275 asthma costs in Finland between different stakeholders has changed considerably with an
276 increase in drug costs and costs for outpatient visits in primary care, but with significant
277 decreases in hospital costs and indirect costs in terms of disability pensions and sickness
278 allowances. A holistic view is warranted and co-operation is needed among those who provide
279 care and pay the costs (40). Focusing on risk groups may provide further improvements (41).

280 Our study has limitations, and the financial results are probably underestimated. Patients with
281 mild or intermittent asthma not requiring daily maintenance treatment were excluded as they are
282 not entitled to drug reimbursement and not included in the registry. The costs due to outpatient
283 visits to private health care providers are not known. Also, many of the components of
284 productivity loss could not be calculated.

In Finland, the number of patients receiving reimbursement for asthma drugs, i.e. those on maintenance treatment, has almost tripled over the 26 years covered by this study. During the same period, the overall healthcare cost index increased by 37.5 % in real terms (15). Despite this, total costs for asthma in Finland at the end of the period were significantly less than 26 years before. In comparison, over the same period, the costs of breast cancer have increased by 140 % while the number of patients has doubled (42). From 2000 to 2007, the direct healthcare costs for diabetes rose by 60 % and costs for disability by 50 % (43).

In the US evaluation methods have been developed that consider health care costs from the perspective of payers and society. However, it has been argued that an analysis of societal costs for a single disease is of little value and cost effectiveness analyses, involving both costs and outcomes, would be more feasible (44). Cost of illness investigations are, nevertheless, valuable in the planning, decision making, and allocation of resources within health care systems (45). A broad societal approach that demonstrates the real health care expenditures is important when discussing interventions in public health and medical care (46). The present paper estimates cost of illness changes over a long period of time, when systematic nationwide intervention has significantly reduced asthma burden.

Conclusions

Asthma needs public health solutions with implementation of best clinical practices. In Finland, a nationwide management program, based on a better understanding of disease pathophysiology resulted in improved care and significant cost savings over a 26-year period. Special focus on particular at-risk groups may provide further improvements.

Key messages

1. In many countries there have been major improvements in asthma care. The Finnish experience indicates that effective implementation of best practice results in significant cost savings. Emphasis on early diagnosis and anti-inflammatory treatment paved the way for improved care.
2. Major societal cost savings can be achieved by reducing disability caused by asthma.
3. Collaboration between all stakeholders is essential to tackle a public health problem like asthma.

Legends for figures

Figure 1. Overall annual costs of asthma care at society level in Finland from 1987 to 2013.

Figure 2. Overall annual costs of asthma care at patient level in Finland from 1987 to 2013.

Figure 3. The actual (realized) annual expenditures of asthma care (blue columns) and the min (red columns) and max scenarios (grey columns) of theoretical annual costs. The min scenario represents a theoretical annual expenditure, if all of the three-fold increase in prevalence was caused by patients with mild asthma. The max scenario assumes that the disease severity and standard of care remained at the 1987 level. The green line represents the percentage of patients on inhaled corticosteroid (ICS) medication.

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Box 1. Asthma program in Finland 1994-2004. Goals and main themes in 1994 (8).

GOALS for prevention, treatment and rehabilitation

1. As many patients as possible with early asthma recover
2. Asthma patients feel well, and their capacity corresponds with age
3. Percentage of patients with severe and moderate asthma falls from 40 % to 20 %
4. Number of hospital days of asthma patients decreases by 50 % by the year 2000
5. Annual costs per patient fall by 50 % as a result of more effective prevention and treatment

MAIN THEMES

- Early diagnosis and anti-inflammatory treatment. "Hit early and hit hard"
 - Guided self-management to stop exacerbations proactively
 - Effective networking with general practitioners, nurses and pharmacists (nomination of asthma-responsible healthcare workers)
 - Smoking and tobacco smoke decreased by legislation
 - Knowledge of asthma increased in key groups
 - Scientific research promoted
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Table 1. Demographic data of the asthma patients in the Finnish drug reimbursement register 1987, 2000 and 2013.

	1987*	2000	2013
Finnish population (million)	4.9	5.2	5.4
Number of patients	83 000	190 383	247 583
Females, %	not available	53.9 %	53.2 %
Prevalence, %	1.6 %	3.6 %	4.4 %
Age groups, %			
• 0-15 years	10 %	14 %	7 %
• 16-64	63 %	56 %	55 %
• 65-	27 %	30 %	38 %
Prevalence in the age group, %			
• 0-15 years	0.8 %	2.9 %	2.0 %
• 16-64	1.6 %	3.1 %	3.8 %
• 65-	3.5 %	7.3 %	8.9 %

* The prevalences denote those patients with the need of long-term regular maintenance medication for asthma control.

Table 2. Total costs per patient and for the Finnish asthma population included in the Finnish drug reimbursement register (83 000 patients in 1987 and 247 583 patients in 2013).

	1987		2013	
	Per patient	Total	Per patient	Total
Total direct costs	1 081 €	89 698 974 €	545 €	134 985 376 €
Hospitalization				
- secondary care	295 €	24 477 526 €	21 €	5 209 985 €
- primary care	69 €	5 729 962 €	11 €	2 720 238 €
Outpatient care				
- secondary care	293 €	24 353 930 €	97 €	24 013 817 €
- primary care	17€	1 152 583 €	22 €	5 472 336 €
Medication	409 €	33 984 973 €	394 €	97 569 000 €
Total indirect costs	1 589 €	131 907 761 €	226 €	55 838 337 €
(Lost productivity)				
Total direct and indirect costs	2 670 €	221 606 735 €	771 €	190 823 713 €

540 **Contributor statement**

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542 T Haahtela – reporting the work, data analysis, clinical expertise, guarantor

543 F Herse – planning, conducting and reporting the work, data analysis

544 J Karjalainen – data analysis, literature search, reporting the work

545 T Klaukka[†] – clinical and health care financing expertise

546 M Linna – health care statistics, data analysis

547 R-L Leskelä – data analyses, reporting the work

548 O Selroos – data analysis, literature search, drafting the manuscript, reporting the work, clinical
549 expertise

550 E Reissell – data analysis, literature search, reporting the work.

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553 **Ethics committee approval**

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555 In this public register based study, no ethics approval was necessary according to Finnish
556 guidelines.

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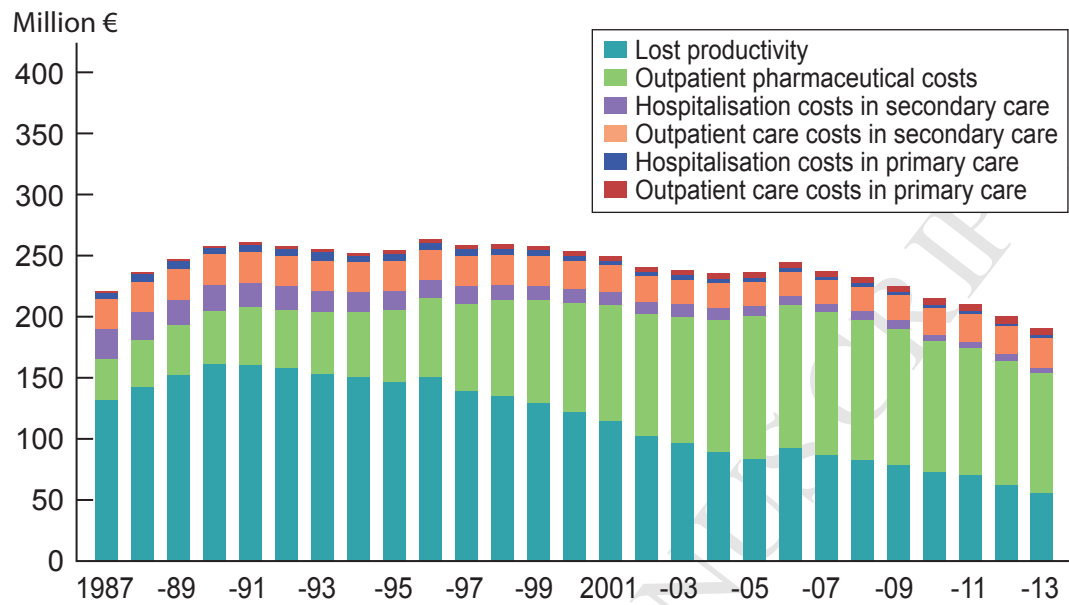
Sources of funding for the study

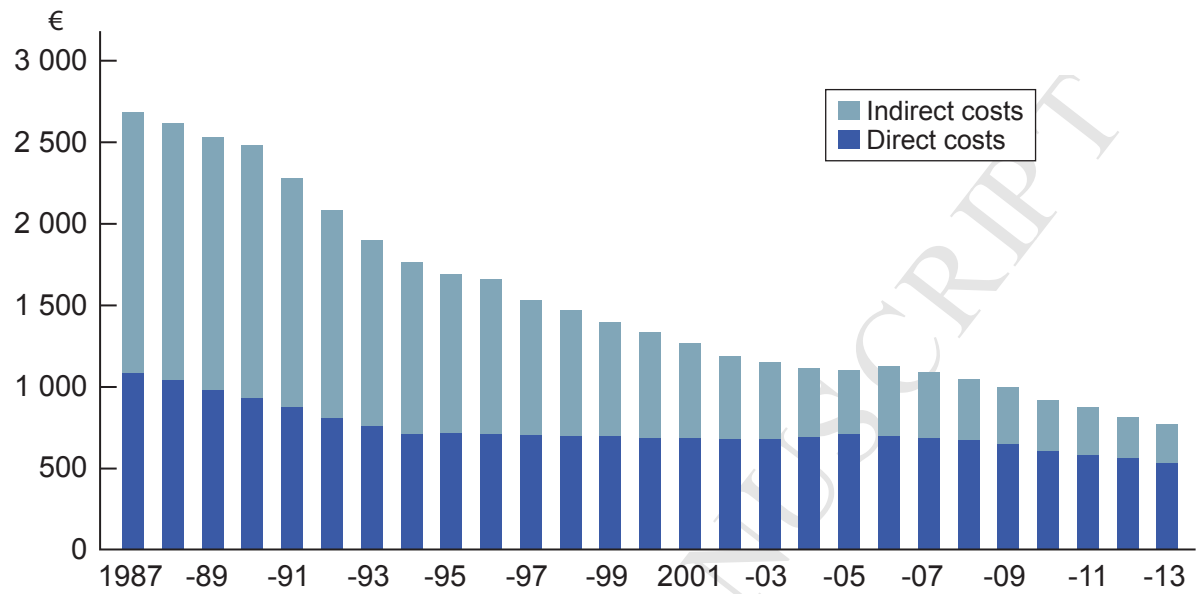
The basis of the present report of asthma care costs in Finland is derived from the governmental, public health care asthma programme 1994-2004 (main results published in Thorax 2001 and 2006). The cost analyses were further developed in a project concerning several common diseases of public health concern commissioned by the Pharma Industry Finland (PIF) with the help of Nordic Healthcare Group (NHG). PIF published a report of the study findings of the selected chronic diseases, asthma among them. PIF did not participate in the design of the present, extended asthma study or in the collection, analysis, and interpretation of data. Preliminary asthma data were published in the Finnish Medical Journal in Finnish (Reissell E, et al. The price of asthma in Finland 1987-2005 – costs and financial benefits of treating a chronic disease. FMJ 2010;65:811-816). PIF had no part in the decision to submit the article for publication and no funding was received. The researchers worked independent of PIF or other funders during the preparation of the present article.

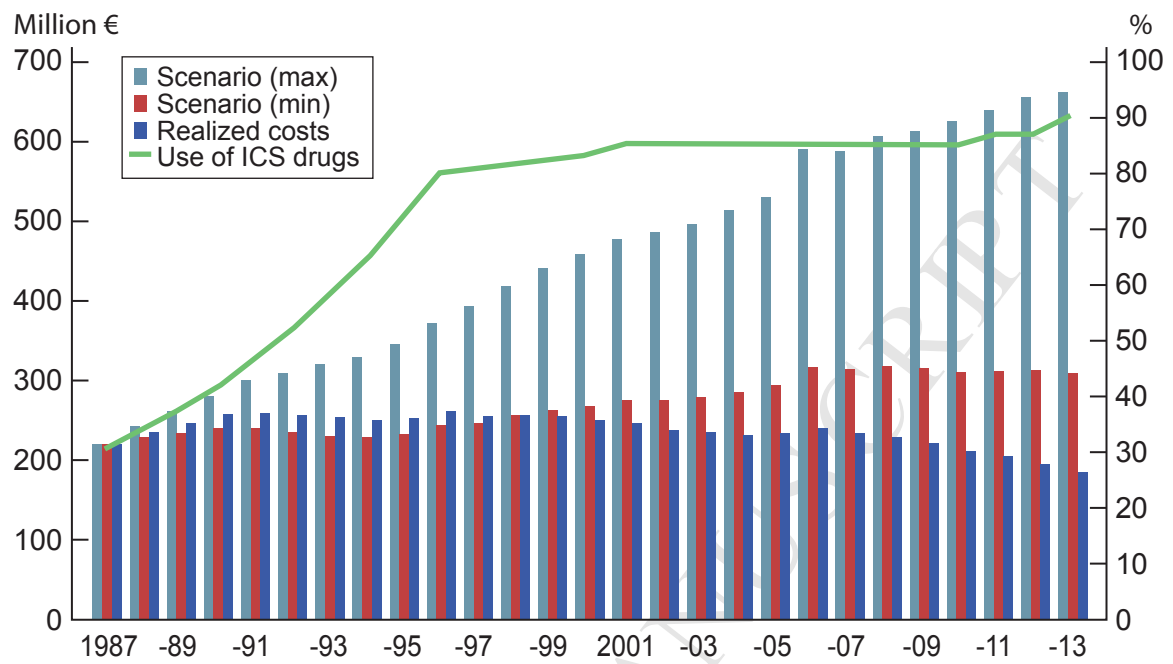
The final stage of this work was supported by the European Commission's 7th Framework Programme under grant agreement 261357 (MeDALL-project) and Helsinki University Hospital grant..

All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Technical appendix, statistical code, and dataset are available by request from Fredrik Herse at fredrik.herse@nhg.fi.







Supplementary Table (online). The Finnish data sources registries and estimation methods for the present work.

	Outcome/cost measure	Data source	Data extraction rule (method)	Cost estimation method	Generalizability (time/area)	Comments/data quality
Direct costs	Inpatient secondary care	National discharge register	Principal dx ICD-9: 493 (1987-1995), ICD-10: J45, J46 (1996-2013). Number of bed-days for each individual	Cost based on total number of bed-days x standard unit price (national standard price list) (14)	Covers all admissions in the country during 1987-2013. Healthcare cost index (15) was used to estimate unit costs in other study years and the general price index (15) for deflating the costs for other study years in 2013 terms	Widely used and audited register, data quality good according to validity studies
	Inpatient primary care	National discharge register	Principal dx ICD-9: 493 (1987-1995), ICD-10: J45, J46 (1998-2013). Number of bed-days for each individual	Cost based on total number of bed-days x standard unit price (national standard price list) (14)	Covers all admissions in the country during 1987-2013. Healthcare cost index (15) was used to estimate unit costs in other study years and the general price index (15) for deflating the costs for other study years in 2013 terms	Widely used and audited register, data quality good according to validity studies
	Outpatient secondary care	National discharge register	Principal dx ICD-10: J45, J46 (1996-2013). Number of visits for each individual	Cost based on total number of visits x standard unit price (national standard price list) (14)	Covers all specialist level ambulatory visits in the country during 1996-2013. Visits in years 1987-1995 were extrapolated assuming a constant growth rate based on the average growth rate in 1996-2013. Healthcare cost index (15) was used to estimate unit costs in other study years and the general price index (15) for deflating the costs for other study years in 2013 terms	Widely used and audited register, data quality good according to validity studies. Uncertainty related to estimated volumes for 1987-1995.
	Outpatient primary care	Nordic Healthcare Group (NHG) benchmarking database (2013)	Dx ICD-10: J45, J46, ICPC-2: R96 (2013). Number of visits for each individual	Average unit cost for ambulatory visit in public health centers (14)	Database contains a representative sample of Finnish municipalities. The number of visits in the whole country was estimated by scaling the number of visits in the sample population to the whole population. Number of other study years were obtained by	Data validated by the municipalities' officials

					assuming that visits per patient have remained constant (visits per patient x number of patients). Healthcare cost index (15) was used to estimate unit costs in other study years and the general price index (15) for deflating the costs for other study years in 2013 terms.	
	Medication (outpatient)*	Finnish statistics on medicines, Finnish medicines agency (Fimea), Social insurance institution (SII)	SII reimbursement code 203 (asthma)	Costs directly from statistics.	Covers medication reimbursements in the whole country (1987-2013). The general price index (15) for deflating the costs for other study years in 2013 terms.	SII registry is reliable because it is based on paid reimbursements and match with accounting data.
Indirect cost (productivity)	Sick leaves	SII Statistical yearbooks	Principal dx ICD-9: 493 (1989-1995), ICD-10: J45, J46 (1996-2013). Number of sick leave days for each individual	Number of sick leave days transformed into lost work years x average annual income (national statistics) (15).	Covers sick leaves longer than 14 days in the whole country for 1989 - 2013. 1987 and 1988 assumed to be the same as 1989. The general price index (15) was used for deflating the costs for other study years in 2013 terms.	SII registry is reliable because it is based on paid reimbursements and match with accounting data.
	Disability pensions	SII statistical yearbooks (National insurance pension). Finnish centre for pensions registry (employee pension)		Number of disability pensions X average annual income (national statistics) (15).	Covers disability pensions (national insurance pension and employee pension) in the whole country for 1987 -2013. The general price index (15) was used for deflating the costs for other study years in 2013 terms.	SII registry and Finnish centre for pensions registry are reliable because they are based on paid reimbursements and match with accounting data.

*Inpatient medication included in inpatient care costs