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Does increased health care spending afford better health care outcomes?

Evidence from Austrian health care expenditure since the initiation of DRGs

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Summary

AIMS: While it is commonly accepted that health care costs have been rising to unprecedented levels, the question remains whether the increased expenditure actually affords increased health outcomes. It was the objective of this study to search for associations between health care spending and health care outcome, after adjusting for potential confounding variables, using aggregate data collected since the introduction of diagnosis-related groups (DRG) into Austrian health care financing in 1997.

METHODS: Two parameters of health care outcome, mortality and years of life lost (YLL), were regressed on direct and indirect measures of health care spending. We used ordinary least squares, Prais-Winsten, and 2-stage least squares regression in model building to account for autocorrelation and endogeneity.

RESULTS: Our findings showed that health care spending was associated with mortality and YLL reduction. The strongest association among the independent variables was seen for spending for prevention. The strongest association for the dependent variables was seen for cardiovascular disease followed by injuries. Also, socio-economic status (SES) was shown to be an important confounder in all studied associations. Our data suggest that increases in health care spending produce significant increases in health.

CONCLUSION: Health care spending should not be constrained, but instead an optimised resource allocation would afford an increase in health per expenditure. Emphasising spending in prevention and reduction of SES gradients would strengthen this association.

Key words: *health care spending; health outcomes; regression modeling; resource allocation*

Introduction

The most pressing policy issue now, and for the foreseeable future, is economic crises in the face of sovereign debt and exploding cost. A major contributor to these problems are rising health care costs and the question of how to deal with and finance them [1–4]. Below the problem of how to deal with rising health care costs lies the, maybe even more pressing, question of whether these increases in health care spending actually result in increased health care output, or whether they merely reflect an inflated administration, expensive technologies, poor comparative effectiveness, or, finally, personal financial advantages for interest groups or individuals [5–7].

Historically, a number of investigators have tried to answer the question [5, 8]. Interestingly, this research has yielded rather inconsistent, if not openly conflicting, findings. Nolte and McKee [9], as well as Nixon and Ulman [10] provided comprehensive overviews of such studies investigating the effect of health care on health outcomes. It is important to note that the brunt of this research was done within the British NHS or similar systems (i.e. tax funded, government controlled and socialised medicine) begging the question of whether the presented findings are representative, thus applicable, for a two-tier health care system with a public option and a strong private component. The Austrian health care system is constituted by a universally accessible, tax-funded public system, and a parallel private system, accounting for roughly 25% of the total health care spending, with practically unrestricted direct patient access to secondary and tertiary care. It was the objective of this study to investigate whether the increasing health care expenditure in such a system is associated with improved health care outcomes.

Materials and methods

Theoretical background

Diagnosis-related group (DRG) is a system to describe and classify services and treatments which a hospital provides and a patient receives, developed with the intent to replace "cost-based" reimbursement for hospitals and to create a more standardised, more transparent, and eventually more cost-effective reimbursement system for intramural health care provision. A nationwide coverage of DRG in Switzerland (SwissDRG per article 49 KVG) is planned for January 2012. Austria implemented a nationwide DRG system called LKF (Leistungsorientierte Krankenanstalten Finanzierung) in 1997, and LKF covers reimbursement for health care provision for approximately 90% of all Austrian patients according to Statistic Austria (www.statistikaustria.at). A recent publication in Swiss Medical Weekly showed that such changes from fee-for-service to DRG are associated with a 20% reduction in length of hospital stay, and thus a considerable reduction in associated cost (11). We wanted to use this chance to study the associations between health care input and output in this DRG system.

For the purpose of this study we defined the production function of health care simplified as:

$$\text{Health outcome} = \beta_0 + \beta_1(\text{health input}) + \beta_2(\text{confounders}) + \varepsilon$$

β_0 = intercept;
β_1 = coefficient for primary exposure
β_2 = coefficient for secondary exposure(s)/confounders
ε = error term

This production function was approached mathematically in three steps. First, ordinary least squares (OLS) regression was performed to study the effect of monetary health care input on health care outcome and health production. Second, these OLS models were assessed for autocorrelation (i.e. correlation between the error terms for the individual years of this time series) using the Durbin-Watson test [12–14]. In the presence of evidence for autocorrelation, Prais-Winsten regression was used to adjust standard errors [12, 14, 15]. Third, there is a risk for endogeneity, which means a correlation between independent variables. To avoid such bias a 2-stage least squares (2SLS) regression using instrumental variables was used [16–21]. The instrumental variable (IV) is associated with one independent variable only. Thus, if an association is found between the IV and the dependent variable, it can only occur via the instrumented independent variable. In our analysis, we used a 2-stage least squares regression with the number of pensioners and total social insurance expenditure without health care costs as IVs. They are intuitively appealing because of the obvious and credible association between pensions and social insurance on the one hand, and health care spending on the other side.

Choice of variables and data sources

The dependent variables of this study were health care outcomes and were studied through the parameters mortality and years of life lost (YLL). Mortality (age adjusted per 100,000) and infant mortality (per 10,000) were included in the study. YLL are an estimate of the average years a person would have lived if he/she had not died prematurely, that is before the statistical mean life expectancy, from a specific cause [22]. YLL give the actual loss to a society due to the burden of disease since this parameter includes age, and gives higher values for younger ages. YLL were calculated for three disease entities: cardiovascular disease, injuries and poisoning, and malignancies. These disease entities were chosen to reflect health care spending for chronic disease (cardiovascular), public spending in an emergency setting (injuries and poisoning) and public spending in specialised centers (malignancies). They were identified by their respective ICD-10 codes: I00-I99 for cardiovascular disease, S00-T98 for injuries and poisoning, and C00-D48 for malignancies.

The explanatory variables for this study were health care expenditure, as total, total public, total private, and total spent in prevention. Furthermore we included the following parameters of socio-economic status (SES) as potential confounders: income inequality (as a ratio of total income received by top quintile to that received by the lowest quintile), risk of poverty after social transfers (persons with an equivalised disposable income, after social transfer, below the risk-of-poverty threshold, where pensions and retirement were counted as income, not a social transfer), and youth education attainment (population aged 20 to 24 having completed at least upper secondary education). The number of pensioners and total social insurance expenditure without health care costs were used as instrumental variables (IVs) in the 2SLS regression (table 1).

Data were obtained from three different sources for the years since the introduction of "Leistungsorientierte Krankenanstaltenfinanzierung" (LKF – the Austrian DRG system) in 1997. National data were obtained from Statistics Austria (www.statistik.at) and the 2009 Manual of the Austrian Social Insurance (*apps.who.int/medicinedocs/documents/s17235de/s17235de.pdf*). These data were matched against, or supplemented by, data published by the Organisation for Economic Co-operation and Development (OECD, http://stats.oecd.org/health), and Eurostat (http://epp.eurostat.ec.europa.eu/portal/page/portal/ structural_indicators/introduction), a Directorate-General for statistics of the European Commission (table 2).

All calculations were done using intercooled STATA 10 (StataCorp LP, College Station, TX). An alpha value of 5% was considered significant for statistical inference. Results are given as coefficient (s.e.).

Results

Health care spending and health care outcomes since DRG introduction.

From 1997 to 2008, mortality remained rather constant with a small annual decrease of 0.6% on average. A sharp decline in YLL was seen for cardiovascular disease (5.4% less per year) and injury and poisoning (2.8% less per year). Similar to total mortality, YLL due to malignancies decreased only marginally by 0.7% annually (table 2).

Overall health care expenditure has grown continuously since 1997 by 3.9%, with equal growth in public and private spending, increasing from 9.8% GDP to 10.2%. The least growth was seen in private spending for administration, at 0.5%, compared to 3.8% in the public sector. The largest relative growth in health care expenditure was seen in prevention with 7.2%, although this amounts to only 2% of total public spending on average (table 2).

OLS modeling

OLS analyses showed statistically significant, negative associations of all direct measures of health care expenditure with the outcomes mortality, infant mortality and years of life lost. In terms of absolute size, spending for prevention invariably afforded the largest improvement in all health care outcomes by far. The second most influential variable was private health care expenditure. YLL due to cardiovascular disease and injury were most responsive to health care expenditure, with a much smaller response for YLL due to malignancies (table 3).

Prais-Winsten modeling

The Durbin Watson test suggested negative autocorrelation for mortality, cardiovascular YLL and years of life lost to malignant disease. No or only little evidence for autocorrelation was seen for infant mortality and YLL due to malignant disease and injury. Even after adjusting, the possibility of residual autocorrelation remained. Table 4 summarises the d statistics for the OLS and the adjusted Prais-Winsten regression.

Although the Durbin Watson test suggested at least some degree of autocorrelation, its effects seemed to be fairly low. The adjusted regression outcomes did not differ much from the OLS. Generally, the coefficients were attenuated, and the standard errors were larger, resulting in larger *p*-values. All but one association (expense for prevention and cardiovascular YLL) remained significant. As seen in the OLS, prevention showed the largest coefficients, suggesting the strongest response, before private, public and total spending. However, while OLS suggested cardiovascular YLL to be the most responsive health care outcome, Prais modeling suggested that YLL due to injury are more responsive.

Multivariate Prais-Winsten modeling

We adjusted the association for health care outcomes and health care expenses for three parameters of socio-economic status (SES): income inequality, at risk of poverty after

Table 1: Description of the included variables.

Variable	Description	mean	SD
mortality	Total mortality per 100,000, age-adjusted	476.91	42.22
infant_mort	Infant mortality per 10,000	43.19	4.79
yll_cardio	YLL (to 80 years of life) lost to cardiovascular disease	133,649.10	34,543.62
yll_injury_poisoning	YLL (to 80 years of life) to injury and poisoning	103,097.10	12,884.05
yll_malignancy	YLL (to 80 years of life) lost to malignant disease	181,341.20	4,537.28
euro_total	Total health care expense (in EURO)	23,014.66	3,389.25
euro_public	Public health care expense (in EURO)	17,516.56	2,592.43
euro_private	Private health care expense (in EURO)	5,498.13	804.25
euro_admin	Administrative health care expense (in EURO)	839.03	101.69
euro_prev	Health care expense for Prevention (in EURO)	350.74	88.84
income_inequality	Inequality of income distribution (top quintile population income/ lowest quintile population income)	3.69	0.19
poverty_risk	At-risk-of-poverty rate after social transfers by gender – %	12.45	0.52
youth_edu	Youth education attainment level by gender – % population aged 20–24 with at least upper secondary education	84.73	1.12
retired	Number of retired individuals (in Millions)	2.03	0.71
social_sec	Total social security expense	36,701.37	4,913.41

Table 2: Development of the included variables over the study period.

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
mortality	545.3	530.5	521.2	503.5	481.2	479.2	481.5	456.6	448.4	431.9	425.3	418.3
infant_mort	47.4	49.2	43.6	48.3	48.4	40.6	44.6	44.7	41.8	36.1	36.7	36.9
yll_cardio	185,491.0	178,516.0	174,196.5	159,617.5	153,631.5	131,375.0	115,689.5	103,799.5	105,076.5	101,304.5	100,657.5	94,434.5
yll_injury_poison	121,863.5	110,464.5	117,666.5	118,818.0	107,878.0	106,462.0	101,437.5	95,612.0	95,668.5	90,388.5	89,185.0	81,721.5
yll_malignancy	187,695.5	184,656.5	185,355.0	184,575.0	180,658.5	180,753.5	183,430.5	185,039.5	179,220.0	174,471.5	174,593.0	175,646.0
euro_total	18,017.7	19,054.6	20,033.0	20,641.7	21,438.1	22,134.2	22,980.4	24,230.3	25,340.1	26,328.8	27,452.9	28,524.2
euro_public	13,635.7	14,483.7	15,375.2	15,859.7	16,312.9	16,777.3	17,355.6	18,341.1	19,294.5	19,970.9	20,977.2	21,814.9
euro_private	4,382.0	4,570.9	4,657.8	4,782.0	5,125.2	5,356.9	5,624.8	5,889.2	6,045.6	6,357.9	6,475.7	6,709.7
euro_prev	212.1	254.3	264.6	271.2	317.7	330.4	366.1	412.5	409.9	427.8	454.9	487.5
income_inequality	3.6	3.5	3.7	3.4	3.5	3.7	4.1	3.8	3.8	3.7	3.8	3.7
poverty_risk	13.0	13.0	12.0	12.0	12.0	12.0	13.0	13.0	12.0	13.0	12.0	12.0
youth_edu	81.8	84.4	84.7	85.1	85.1	85.3	84.2	85.8	85.9	85.8	84.1	84.5
retired	1.93	1.95	1.96	1.98	1.99	2.01	2.02	2.04	2.07	2.1	2.13	2.15
social_sec	29,639.5	30,710.0	32,114.0	33,530.0	34,728.0	35,847.0	36,901.0	38,012.0	39,441.0	41,018.0	43,105.0	45,371.0

Table 3: Results from the three different regression models.

Outcome	Determinant	OLS		Prais-Winsten/ Cochrane-Orcutt		2SLS	
		Coef (s.e.)	*p*-value	Coef (s.e.)	*p*-value	Coef (s.e.)	*p*-value
Mortality per 100,000	Total expenses	–0.01 (0.0)	<0.001	–0.01 (0.0)	<0.001	–0.01 (0.0)	<0.001
	Public expenses	–0.02 (0.0)	<0.001	–0.02 (0.0)	<0.001	–0.02	<0.001
	Privat expenses	–0.05 (0.0)	<0.001	–0.05 (0.0)	<0.001	–0.05 (0.0)	<0.001
	Prevention	–0.47 (0.03)	<0.001	–0.46 (0.0)	<0.001	–0.5 (0.0)	<0.001
Infant mortality per 10,000	Total expenses	–0.001 (0.0)	<0.001	–0.001 (0.0)	<0.001	–0.001 (0.0)	<0.001
	Public expenses	–0.002 (0.0)	<0.001	–0.002 (0.0)	<0.001	–0.002 (0.0)	<0.002
	Privat expenses	–0.005 (0.0)	<0.001	–0.005 (0.0)	<0.001	–0.01 (0.0)	<0.001
	Prevention	–0.04 (0.0)	0.002	–0.04 (0.0)	0.002	–0.05 (0.0)	<0.002
YLL, cardiovascular disease	Total expenses	–9.7 (1.0)	<0.001	–8.5 (1.6)	<0.001	–9.7 (0.9)	<0.001
	Public expenses	–12.5 (1.5)	<0.001	–10.5 (2.3)	0.001	–12.7 (1.3)	<0.001
	Privat expenses	–41.7 (3.3)	<0.001	–27.1 (11.0)	0.036	–41.1 (3.1)	<0.001
	Prevention	–377.7 (29.3)	<0.001	–43.9 (123.8)	0.731	–373.2 (27.2)	<0.001
YLL, malignant disease	Total expenses	–1.2 (0.2)	<0.001	–1.1 (0.3)	0.007	–1.2 (0.2)	<0.001
	Public expenses	–1.5 (0.3)	<0.001	–1.5 (0.4)	0.005	–1.5 (0.3)	<0.001
	Privat expenses	–4.8 (0.9)	<0.001	–4.5 (1.5)	0.015	–5.0 (0.9)	<0.001
	Prevention	–42.0 (9.2)	0.001	–36.5 (16.2)	0.051	–45.0 (8.6)	<0.001
YLL, injuries and poisoning	Total expenses	–3.7 (0.3)	<0.001	–3.6 (0.3)	<0.001	–3.6 (0.3)	<0.001
	Public expenses	–4.7 (0.5)	<0.001	–4.7 (0.5)	<0.001	–4.8 (0.4)	<0.001
	Privat expenses	–15.6 (1.1)	<0.001	–15.2 (1.0)	<0.001	–15.5 (1.0)	<0.001
	Prevention	–141.9 (9.4)	<0.001	–141.9 (9.3)	<0.001	–140.6 (8.7)	<0.001

* no convergence

Table 4: Results for the Durbin Watson statistic.

Outcome	Determinant	d-statistic OLS	adjusted d-statistic – Prias Winsten
Mortality per 100,000	Total expenses	1.188	1.655
	Public expenses	1.182	1.704
	Privat expenses	1.096	1.466
	Admininstrative	0.767	1.336
	Prevention	1.254	1.384
Infant mortality per 10,000	Total expenses	2.419	2.168
	Public expenses	2.424	2.18
	Privat expenses	2.332	2.102
	Admininstrative	2.130	2.083
	Prevention	2.227	2.057
YLL, cardiovascular disease	Total expenses	0.532	1.243
	Public expenses	0.528	1.186
	Privat expenses	0.665	1.656
	Admininstrative	0.648	1.442
	Prevention	1.130	1.937
YLL, malignant disease	Total expenses	1.477	1.529
	Public expenses	1.536	1.567
	Privat expenses	1.289	1.418
	Admininstrative	1.407	1.607
	Prevention	1.308	0.1484
YLL, injuries and poisoning	Total expenses	2.190	2.062
	Public expenses	2.078	2.022
	Privat expenses	2.413	2.135
	Admininstrative	2.144	1.752
	Prevention	1.964	1.948

*no convergence

social transfers, and youth education attainment (see table 1 for further explanation). The association between infant mortality and expenses was independent of all three parameters. For mortality, we saw that youth education was a significant covariate for total and private spending. For the latter, income inequality also showed a significant association. However, adjusting for SES did not notably change the coefficients in the associations between any type of expense and mortality.

For YLL, the strongest confounding variable was seen for income inequality and the associations between health care spending and YLL lost to malignant disease. These numbers suggest that higher income inequality leads to more YLL to malignant disease. Adjusting for income inequality also increased the coefficients for the regression of malignant disease YLL on expenses, suggesting that income inequality reduces the effect of spent money on preventing loss of life to malignancies.

The association between cardiovascular YLL and health care spending was widely independent from SES. Only the association between private expense and cardiovascular YLL was affected by income inequality and youth education, in such a way that increases in both decreased YLL significantly.

The association between YLL due to injury and poisoning was also confounded by SES. Interestingly, poverty risk seemed to reduce YLL. The adjusted coefficients for the association between YLL and expenses increased after the inclusion of SES into the model.

Table 5 gives detailed information on all multivariate analyses.

2SLS modeling

As with Prais Winsten regression, OLS and 2SLS produced rather consistent results suggesting only very little endogeneity. As seen in the OLS model, all direct measures of health care expenditure were associated with health care outcomes. 2SLS confirmed the earlier seen trend that cardiovascular YLL are most responsive to health care expenditure, before trauma and malignant YLL, and mortality. Also, expense in prevention produced a substantially higher effect on all health care outcomes than any other type of spending.

Multivariate 2SLS modeling

Multivariate 2SLS assessment of the association of health care outcomes with health care expenditure including SES showed similar results to what was seen for the Prais-Winsten regression. Youth education attainment and income inequality had significant influence on the association between mortality and health care spending in all four areas, total, public, private and prevention. This influence had the same direction as in the Prais Winsten model, youth education negative and income inequality positive, but featuring somewhat larger absolute numerical values. There was no multivariate influence on the association of health care spending and infant mortality.

The effect of health care spending on cardiovascular YLL was confounded by all three SES parameters. Higher income inequality resulted in substantially higher cardiovascular YLL. Higher youth education attainment resulted in a considerable reduction of YLL, but, interestingly, so did poverty risk.

Income inequality also resulted in more malignant disease YLL, and was a significant confounder of the association between this health outcome and health care expenditure, with considerable increase in size for the adjusted coefficients.

SES was also a significant confounder for the association between YLL due to injury and poisoning, with, again, a fair increase in the size of the adjusted coefficients. Table 5 gives detailed information on all multivariate analyses.

Discussion

It was the objective of our study to search for an association between health care expenditure and health outcomes. In our analysis we found evidence that the increase in health care expenditure in Austria between 1997 and 2008 was associated with reductions in mortality and years of life lost. The biggest effect size by far was seen for marginal expense in prevention, roughly one order of magnitude bigger than the effect of both public and private expenses. Also, socio-economic status proved to play an important role in the association between health care expenditure and health care outcome, especially years of life lost. Together, these data suggest the health care (allocative) efficiency could be improved by emphasising prevention and flattening socio-economic gradients.

This study has potential shortcomings. First, the observation period of 12 years (1997–2008) is somewhat short. However, it should be considered that before 1997 a different system was used for Austrian health care finance, and comparison across this timeline is invalid. Moreover, Austria joined the EU in 1995, which might have had a considerable effect on health care costs, performance, and documentation, which further inhibits the inclusion of earlier years into this study. Our model also encompasses a limited set of variables. Health care is a highly complex field, and we could have included numerous other disease entities, as well as demographic or economic variables. However, we decided to use a lean model that might give a limited, but less crowed view. It is also noteworthy that we did not include comparative-effectiveness or cost-effectiveness into our analysis, but we think it is obvious that more effective technologies and systematic processes would produce better health at relatively less cost [6, 7].

Our methodological approach might seem somewhat complicated, but we wanted to offer as complete a view on the data as possible. The initial OLS regression describes significance and magnitude of effects on health outcomes but does not account for autocorrelation or endogeneity. Autocorrelation occurs in time series and can be thought of as a cross-correlation of a variable with itself, for example, mortality in all Austrians in 2001 is likely to correlate with mortality in all Austrians in 2000 or 2002, since it is the same group of people, just one year younger or older. The Prais-Winsten regression accounts for this, and its coefficients are representative for the whole period, while the coefficients from the OLS regression should rather be used for individual years. After addressing autocorrelation we needed to deal with endogeneity, which is the fact that

health care output and health care input is a bit of a chicken-or-egg causality dilemma and cannot fully be separated. The 2SLS regression borrows other predictors that represent health care input to test the regression model, by turning it into a rooster-or-egg problem. Thus all three models add valuable information on potential biases and the differences in coefficients between these models illustrate the magnitude of influence of these biases.

Synthesising the information from all three regression models, our data suggests that health care spending is associated with mortality, both overall and for infants, and that increases in spending decrease mortality rates. However, since life expectancy and the overall health in the studied population, like in most wealthy nations, were rather high to begin with there was only so much reduction in mortality possible [23]. This, on the one hand, explains why the absolute values for the association between mortality and health care spending were somewhat low. This also explains, on the other hand, why expenditure for prevention, which targets a younger population with more mortality headroom, showed the strongest association. The second largest coefficient was seen for private health care spending. This does not necessarily mean that private health care spending produces better health. It is important to keep in mind that privatised health care in an environment with a public options tends to scoop off the good cases,

Table 5: Results from the multivariate models including SES.

Outcome	Determinant	Prais-Winsten/ Cochrane-Orcutt		2SLS	
	Confounder(s)	**Adjusted Coef (s.e.)**	***p*-value**	**Adjusted Coef (s.e.)**	***p*-value**
Mortality per 100,000	Total expenses	–0.01 (0.0)	<0.001	–0.01 (0.0)	<0.001
	Youth_edu	*–4.2 (1.9)*	*0.057*	*–4.9 (1.7)*	*0.004*
	Public expenses	–0.02 (0.0)*	<0.001	–0.02 (0.0)	<0.001
	Youth_edu	–		*–5.1 (1.9)*	*0.008*
	Privat expenses	-0.05 (0.0)	<0.001	–0.08 (0.0)	<0.001
	Income_inequality	*31.5 (10.4)*	*0.019*	*246.0 (22.3)*	*<0.001*
	Youth_edu	*–4.3 (1.6)*	*0.03*	–	
	Prevention	–0.47 (0.03)*	<0.001	–0.7 (0.1)	<0.001
	Income_inequality	–		*192.2 (9.3)*	*<0.001*
Infant mortality per 10,000	Total expenses	–0.001 (0.0)*	<0.001	–0.001 (0.0)*	<0.001
	Public expenses	–0.002 (0.0)*	<0.001	–0.002 (0.0)*	<0.001
	Privat expenses	–0.005 (0.0)*	<0.001	–0.005 (0.0)*	<0.001
	Prevention	–0.04 (0.0)*	0.002	–0.04 (0.0)*	0.002
YLL, cardiovascular disease	Total expenses	–8.5 (1.6)*	<0.001	–9.6 (0.8)	<0.001
	Income_inequality	–		–	
	Youth_edu	–		*–5851.3 (2519.1)*	*0.02*
	Poverty_risk	–		*–15338.3 (5009.3)*	*0.002*
	Public expenses	–10.5 (2.3)*	0.001	–12.6 (1.1)	<0.001
	Youth_edu	–		*–6,000.0 (2649.0)*	*0.024*
	Poverty_risk	–		*–17158.5 (5315.7)*	*0.001*
	Privat expenses	–41.7 (3.3)	<0.001	–53.5 (10.6)	<0.001
	Income_inequality	*–39,215.8 (22024.8)*	*0.014*	*116,117.7 (15321.7)*	*<0.001*
	Youth_edu	*–4,856.7 (1866.0)*	*0.035*	–	
	Prevention	–43.9 (123.8)	0.731	–373.2 (27.2)	<0.001
YLL, malignant disease	Total expenses	–1.4 (0.2)	<0.001	–2.8 (1.1)	0.007
	Income_inequality	*8,620.5 (3862.1)*	*0.056*	*66,904.5 (6420.7)*	*<0.001*
	Public expenses	–1.5 (0.3)	<0.001	–3.7 (1.4)	0.009
	Income_inequality	*7,593.8 (3871.5)*	*0.085*	*66,825.9 (6513.3)*	*<0.001*
	Privat expenses	–6.4 (0.8)	<0.001	–12.1 (4.3)	0.005
	Income_inequality	*11,959.7 (4014.3)*	*0.018*	*67158.3 (6148.9)*	*<0.001*
	Prevention	–42.0 (9.2)*	0.001	–101.7 (31.5)	0.001
	Income_inequality	–		*58,865.2 (2984.2)*	*<0.001*
YLL, injuries and poisoning	Total expenses	–3.8 (0.2)	<0.001	–3.8 (0.3)	<0.001
	Poverty_risk	*–5,481.5 (1504.8)*	*0.007*	*–4,687.8 (1699.2)*	*0.006*
	Public expenses	–4.7 (0.5)	<0.001	–5.1 (0.3)	<0.001
	Poverty_risk	*–6,524.5 (1496.0)*	*0.002*	*–5551.1 (1755.8)*	*0.002*
	Privat expenses	–15.2 (1.0)	<0.001	–21.8 (4.4)	<0.001
	Income_inequality	–		*60,450.8 (6317.1)*	*<0.001*
	Prevention	–153.1 (11.1)	<0.001	–184.1 (27.8)	<0.001
	Poverty_risk	*–3,959.0 (1876.4)*	*0.073*	–	
	Income_inequality	*–7,629.8 (5961.6)*	*0.241*	*45,439.0 (2631.7)*	*<0.001*

*no mutlivariate associations

i.e. tending to easier cases while leaving the high-risk and complication-prone patients to the public sector. Such a notion of "scoop off medicine" is supported by the fact that the coefficient for public health care expenditure was still higher than that for total expenditure. If the public option was indeed less productive, then its coefficient would consequently lie below that of total expenditure, which, in turn, would show the average value for the "good" private sector and the "bad" public sector.

The potential benefits of increasing spending in prevention deserve individual attention. A recent OECD survey showed that a number of developed countries invest heavily, thus excel, in quality of care for serious disease entities such as cancer, but at the expense of persistently increasing chronic diseases such as asthma, diabetes or obesity [24]. This problem has to be recognised and taken into account by policy makers and health care planers. For example, an additional million Euros invested into the prevention of cardiovascular disease might save 378 years of life, the same amount of money invested in the general public expenditure for cardiovascular disease saves 13 years. This also means, that 1 million Euros shifted from cardiovascular disease to prevention would still result in a net benefit of 365 years of life saved (i.e. roughly EUR 3,000 per life year) [25, 26]. Considering the fact that the British National Institute for Health and Clinical excellence (NICE) defines an incremental cost-effectiveness ratio of EUR 45,000 (GBP 20,000) per QALY as "very cost-effective" emphasises the meaning of these numbers (http://www.nice.org.uk/media/4A6/41/CostEffectivenessThresholdFinalPaperTabledAtWPMeeting5Sep3907KT.pdf).

Stressing the meaning of prevention justifies a closer look at what was done for prevention in Austria during the study period. During the last years of the observed period, the Austrian Programme for Accident Prevention was initiated by the federal ministry of health. This programme aimed at reducing accidents and deaths from accidents by 25% in total and by 50% in the paediatric population. This programme rests on three pillars: providing a safe environment, stimulating responsible behaviour through education, and improving the qualifications of professionals involved in injury prevention and health care. This initiative also included a systematic collection of accident and injury data in a publicly accessible database (http://www.kfv.at/unfallstatistik). By 2010, it had resulted in a 22.6% reduction in traffic accident deaths and a 33% reduction in accident-related deaths at the work place. One particularly interesting and effective public health implementation was the passing of a law requiring the obligatory use of bicycle helmets in Austria. Furian et al. assessed the results of this law and were able to show that in 2006 60% of children and adolescents up to 14 years of age wore helmets whilst on a bike in Austria, compared to 49% in Switzerland [27]. Probst-Hensch et al. recently reported on the UN high-level meeting about non-communicable disease and its implications for Switzerland in Swiss Medical Weekly. They recommend strengthening currently existing efforts through directed legislation concerning prevention and diagnosis registration and the creation of dedicated R&D platforms [28]. A good example for such research is the study by Natterer et al. in Swiss Medical Weekly in 2009 identifying the population at risk and circumstances of paediatric burns [29].

We also included indicators of socioeconomic status (SES), which has been show to be associated with health outcomes. It should be considered that the studied population has a rather high level of social cohesion, and patients receive health care independent from their financial capabilities, or at least in theory. Nevertheless, we found evidence for strong confounding influence of SES on the associations between health care spending and health outcomes. Youth education attainment was associated with reduction of mortality and cardiovascular YLL, which is bio-sociologically plausible, indicating that the higher educated have lower mortality, probably via better lifestyle decisions. The percentage of people at risk of poverty after social transfers was, interestingly, also positively associated with YLL (i.e. higher risk led to lower YLL). The most likely reason for such a counterintuitive finding is residual confounding through another, not documented factor. Also, the percentage of people at risk of poverty is, as the name implies, at risk but not impoverished yet, which might be a stimulus for seeking more medical attention and thus receiving more treatment than people without such risk. Finally, income inequality led to increases in YLL, especially for malignant diseases, which are marked by expensive, both in direct and indirect costs, medication and treatments.

Conclusion

Our study results suggest that the increases in health care expenditure in this population have been associated with improved health outcomes. Prevention was the most influential parameter, a fact that should be considered in health care planning. We want to take a moment to emphasise that this does not mean that increased spending obviates the need for efficacious and equitable resource allocation. Also, our findings must not be interpreted as an invitation to meet rising health care demands merely with money instead of astute policies and thoroughly tested technologies and processes. Quite the opposite is true, and our findings should be interpreted as indictors that increased health care expenditure can be just and justified, but output can only be optimised in combination with data from comparative effectiveness research.

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References

1 Catalano R. Health, medical care, and economic crisis. N Engl J Med. 2009;360(8):749–51.

2 Collier R. Recession stresses mental health system. Cmaj. 2009;181(3–4):E48–9.

3 Janlert U. Economic crisis, unemployment and public health. Scand J Public Health. 2009;37(8):783–4.

4 Tanne JH. Poor economy means more Americans have trouble paying medical bills. Bmj. 2008;337:a1430.

5 Martin S, Rice N, Smith PC. Does health care spending improve health outcomes? Evidence from English programme budgeting data. J Health Econ. 2008;27(4):826–42.

6 Neumann PJ, Tunis SR. Medicare and Medical Technology – The Growing Demand for Relevant Outcomes. N Engl J Med. 2010;362(5):377–9.

7 Weinstein MC, Skinner JA. Comparative Effectiveness and Health Care Spending – Implications for Reform. N Engl J Med. 2010;362(5):460–5.

8 Cochrane A, St Leger A, Moore S. Health service "input" and mortality "output" in developed countries. J Epidemiol Community Health. 1978;32:200–2005.

9 Nolte E, McKee MD. Does health care save lives? The Nuffield Trust, London; 2004.

10 Nixon J, Ulmann P. The relationship between health care expenditure and health outcomes. European Journal of Health Economics. 2006;7:7–18.

11 Schuetz P, Albrich WC, Suter I, et al. Quality of care delivered by fee-for-service and DRG hospitals in Switzerland in patients with community-acquired pneumonia. Swiss Med Wkly;141:w13228.

12 Huitema BE, McKean JW. A simple and powerful test for autocorrelated errors in OLS intervention models. Psychol Rep. 2000;87(1):3–20.

13 Smith DP. Durbin-Watson statistics for model life tables. Asian Pac Cens Forum. 1983;9(4):7–9.

14 Dubin J, Watson G. Testing for serial correlation in least square regression. Biometrika. 1950;37:409–28.

15 Judge G, Griffiths W, Hill R, Lütkepohl H, Lee T. The Theory and Practice of Econometrics. 2nd Ed. New York: Wiley; 1985.

16 Sargan J. The estimation of economic realtionships using instrumental variables. Econometrica. 1958;26:393–415.

17 Cragg J, Donald S. Testing identifiability and specification in instrumental variables models. Econometric Theory. 1993;9:222–40.

18 Peseran M, Taylor L. Diagnostics for IV regresssions. Oxford Bulletin of Economics and Statistics. 1999;61(2):225–81.

19 Johnston KM, Gustafson P, Levy AR, Grootendorst P. Use of instrumental variables in the analysis of generalized linear models in the presence of unmeasured confounding with applications to epidemiological research. Stat Med. 2008;27(9):1539–56.

20 Rassen JA, Schneeweiss S, Glynn RJ, Mittleman MA, Brookhart MA. Instrumental variable analysis for estimation of treatment effects with dichotomous outcomes. Am J Epidemiol. 2009;169(3):273–84.

21 Terza JV, Basu A, Rathouz PJ. Two-stage residual inclusion estimation: addressing endogeneity in health econometric modeling. J Health Econ. 2008;27(3):531–43.

22 Gardner JW, Sanborn JS. Years of potential life lost (YPLL) – what does it measure? Epidemiology. 1990;1(4):322–9.

23 Mackenbach JP, Bouvier-Colle MH, Jougla E. "Avoidable" mortality and health services: a review of aggregate data studies. J Epidemiol Community Health. 1990;44(2):106–11.

24 Health at a glance 2009: OECD indicators [database on the Internet]. 2009. Available from: http://dx.doi.org/10.1787/health_glance-2009-en.

25 Edejer TT, Baltussen R, Adam T, et al. WHO GUIDE TO COST-EFFECTIVENESS ANALYSIS. 2003 Nov 5.

26 Thornton JG, Lilford RJ, Johnson N. Decision analysis in medicine. BMJ1992 Apr 24;304(6834):1099–103.

27 Furian G, Hnatek-Petrak K. http://www.kfv.at/unfallstatistik/. http://wwwkfvat/unfallstatistik/2006;09:427-32.

28 Probst-Hensch N, Tanner M, Kessler C, Burri C, Kunzli N. Prevention – a cost-effective way to fight the non-communicable disease epidemic: an academic perspective of the United Nations High-level NCD Meeting. Swiss Med Wkly. 2011;141:w13266.

29 Natterer J, de Buys Roessingh A, Reinberg O, Hohlfeld J. Targeting burn prevention in the paediatric population: a prospective study of children's burns in the Lausanne area. Swiss Med Wkly. 2009;139(37–38):535–9.