Assessing physician productivity following Norwegian hospital reform: a panel and data envelopment analysis

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Assessing physician productivity following the Norwegian hospital reform: a panel and data envelopment analysis

ABSTRACT

Background:

Although health care reforms may improve efficiency at the macro level, less is known regarding their effects on the utilization of health care personnel. Following the 2002 Norwegian hospital reform, we studied the productivity of the physician workforce and the effect of personnel mix on this measure.

Methods:

We used panel analysis and non-parametric data envelopment analysis (DEA) to study physician productivity defined as patient treatments per full-time equivalent (FTE) physician from 2001 to 2013. Resource variables were FTE and salary costs of physicians, nurses, secretaries, and other personnel. Patient metrics were the number of patients treated by hospitalization, daycare, and outpatient treatments, as well as corresponding diagnosis-related group (DRG) scores accounting for differences in patient mix. Research publications and the fraction of residents/FTE physicians were used as proxies for research and physician training.

Results:

There was a 47% increase in the number of patients treated and a 35% increase in DRG, but there were no significant increases in any of the activity measures per FTE physician. Total DRG per FTE physician declined by 6% ($p < 0.05$). In the panel analysis, more nurses and secretaries per FTE physician correlated positively with physician productivity, whereas physician salary was neutral. In 2013, there was a 12%–80% difference between the hospitals with the highest and lowest physician productivity in the differing treatment modalities. In the DEA, cost efficiency did not change in the study period, but allocative efficiency decreased significantly. Bootstrapped estimates indicated that the use of physicians was too high and the use of auxiliary nurses and secretaries was too low.

Conclusions:

Our measures of physician productivity declined from 2001 to 2013. More support staff was a significant variable for predicting physician productivity. Personnel mix developments in the study period were unfavorable with respect to physician productivity.

Keywords: Physician productivity; Personnel mix; Health care reform; Panel analysis; Data envelopment analysis. Norway.

Introduction

The success of modern medicine may in fact become its most serious challenge. Supported by accelerating technological developments, modern medicine is pushing frontiers at increasing speeds. These rapid advancements may exceed the capacities of economic and human resources available in the future. Novel treatments for new patient groups that seemed impossible a few years ago, along with increasing complexity and specialization, have resulted in a growing demand for health personnel. With the limited workforce and labor supply confronting most developed health care systems, the continued rapid development of medicine may not be sustainable (Cooper 2004, Simoens 2006, Staiger, Auerbach et al. 2009, Staiger, Auerbach et al. 2010, Williams, Sun et al. 2010).

The need to improve efficiency is therefore urgent. To cope with the economic challenges, many financial, political, and organizational investments have been made in most developed health care systems in recent decades (Wilsford 1994, Johnson 1995, Rickman and McGuire 1999, Tuohy 1999, Oliver and Mossialos 2005, Wiley 2005, Busse, Schreyogg et al. 2008, Magnussen 2009, Rumbold 2015). In 2002, aiming to reduce political interference, a Norwegian hospital reform transformed hospitals into enterprises owned by the government but with full autonomy. One of the major goals was to utilize personnel more efficiently by granting hospitals the power to negotiate the salaries of their own staff members and to decide on their own personnel strategies (Biorn 2010, Tiemann and Schreyogg 2012). The intention was to create solutions that would stimulate and reward personnel—physicians in particular—for increasing their competence and clinical efficiency, based on the needs of individual institutions.

Hospital productivity and efficiency have been studied extensively at the institutional level, both within individual health care systems and across different national systems. The approaches taken by these studies vary, with some using advanced techniques such as data envelopment analysis (DEA) and stochastic frontier analysis (SFA) and others relying on less advanced techniques (Hollingsworth 2008, Varabyova and Schreyogg 2013, Castelli, Street et al. 2014, Storfa and Wilson 2015). Some studies have examined efficiency within particular specialties and at the individual level (Bloor, Maynard et al. 2004, Askildsen 2006, Schreyogg 2008, Tiemann 2008, Laudicella, Olsen et al. 2010, Romley, Goldman et al. 2015). However, the productivity of health personnel is difficult to assess because of multiple tasks of patient treatment, teaching and research, and also due to differences across specialties regarding diversity in patient treatments and care levels. No single measure can fully reflect this and we are often left with macro parameters and proxies, such as billing and reimbursement. Furthermore, because productivity is only one aspect of health care systems, it has been suggested that productivity measures should be related to quality and health outcomes (Stecker and Schroeder 2013, Menachemi, Yeager et al. 2015, Romley, Goldman et al. 2015, Sandy, Haltson et al. 2015). However, this may be challenging at the institutional level, where multiple treatment procedures and patient groups are pooled, and past work has found that the link between hospital efficiency and quality varies from a positive association to more mixed results (Yasaitis, Fisher et al. 2009, Stukel, Fisher et al. 2012, Hussey, Wertheimer et al. 2013, Romley, Jena et al. 2013, Heijink, Engelfriet et al. 2015, Kittelsen, Anthun et al. 2015, Menachemi, Yeager et al. 2015, Romley, Goldman et al. 2015).

A possible challenge is that the complex scientific results from DEA or SFA analyses, based on proxies, are not everyday statistics known to health personnel and therefore may have limited impact at the bedside. Hypothetically, measures describing the number of patients to whom the personnel provide service may spark action among “the white coats” in everyday practice and have a supplemental value, despite not having the same scientific basis as more advanced techniques (Rumbold, Smith et al. 2015). An example of such data is illustrated by work from the National Health Service Institute which has revealed that patient admissions and completed consulting episodes per consultant vary by over 100% across different NHS trusts in England (Castelli, Street et al. 2014, Street and Castelli 2014, Aragon, Castelli et al. 2015). If such differences are real, there would be a substantial gain if the lower-level performers could operate at the average level.

A simple description of productivity is the relation between input and output. Whereas the input of health personnel resources may be established through measures of the workforce or salary, the assessment of output is more complex. Metrics as the number of hospital admissions, daycare treatments, and outpatient consultations are not sufficient alone, but as a group they may cover differing pieces of a complex puzzle. However, the large degree of variation between different patient treatments and care levels are not covered. To compensate for this, researchers have used measures thought to reflect some of this variation, such as diagnosis-related groups (DRG), health care resource groups, or relative value units (Biorn 2010, Kentros and Barbato 2013, Castelli, Street et al. 2014).

The extent of physician services available for patient treatment is the crucial issue, and the utilization of physician resources is therefore important. This, in turn, may depend on organizational perspectives as well as personnel mix (Rodysill 2003, Newhouse and Sinaiko 2007, Johnson, Shah et al. 2008, Sunshine, Hughes et al. 2010, Sandbaek, Helgheim et al. 2014, Bank and Gage 2015, Greene 2015). We therefore undertook this study in an attempt to study physician productivity using metrics of patients treated combined with health personnel indicators.

Background

In 2002, all public Norwegian hospitals were transferred from a system of county ownership to central government ownership (Hagen and Kaarboe 2006). The aim was to increase hospital efficiency by providing greater autonomy with respect to planning, budgeting, and workforce policies. The reform aimed to define the hospitals' economic responsibilities more precisely and to implement remuneration for personnel that would stimulate productivity, especially among physicians (Magnussen 2009, Biorn 2010, Verzulli 2011). Hospitals were restructured as health enterprises comprising 1–8 of the previous hospitals, and they were organized into five regional health authorities (RHAs, reduced to four in 2005). During our study period (2001–2013), Norwegian hospitals consisted of five regional university hospitals (the most specialized hospitals, two of which were merged in 2010), 11 central hospitals (two with university functions), and four local hospitals.

The Norwegian health system is funded mainly by general taxation, and hospital care is paid through a mixture of global funding and activity-based funding (ABF) which is mainly based on the DRG system. Hospitals receive targeted compensation for teaching and research.

Aims and objectives

The current study had three aims. First, we investigated whether the utilization of the physician workforce, as assessed by indicators of patient treatment volumes in relation to the number of physicians, has improved since the 2002 hospital reform. Because we did not study the period before the reform was implemented, we had no ambition to examine causality. Second, using panel analysis with limited information maximum likelihood estimations (LIML) (Anderson and Rubin 1949) and the non-parametric DEA method for estimating a variable returns to scale cost function (Charnes, Cooper et al. 1978, Banker, Charnes et al. 1984), we analyzed the relationship between the relative personnel mix (nurses, auxiliary nurses, and medical secretaries) and physician productivity . Third, we examined whether the health reform has been successful in creating a remuneration structure for physicians that translates into physician efficiency (Bloor, Maynard et al. 2004, Devlin and Sarma 2008). In our analyses, we used parameters reflecting patient treatment, research activity and teaching, and related these measures to workforce resources.

Methods

Data sources

The dataset covered the period from 2001, the last year before the reform was implemented, to 2013. All hospital enterprises in Norway (N = 19) were included, and we had data from each hospital each year. Hospital mergers during this period were handled by aggregating the data in the premerger period to the hospital structure in the post-merger period.

Data on workforce resources and salaries were obtained from The Employers Organization Specter and Statistics Norway. Data of personnel resources are described in Table 1. Salary data consist of payment for regular work, casual overtime and on call services.

Activity data were obtained from the Norwegian Patient Register and consist of the total number of treatments, including hospitalization, daycare, and outpatient consultations every year for each hospital, as well as the corresponding number of DRG scores for these care levels. The DRG system groups patients into categories with similar use of resources, and DRG scores reflect the overall costs for the patient treatment episodes including compensation for non-personnel routine operating costs attributable to patient care, medical and technical tools, and overhead costs. The DRG unit price is an estimated average cost of all patients at the national level and the unit for ABF. Since these DRG scores are primarily constructed from a reimbursement perspective they include several factors not related to personnel resources. Accordingly, they are not an exact measure of patient-related workload in relation to personnel productivity.

Table 1

	Variables	Definition	Data Source
Target Dependent in LIMIL	Total DRG/Physician	Sum of DRG scores from hospitalization, day treatment and outpatient consultations per FTE	NPR for activity, Physician FTE from Specter
Regressors in LIML Analysis	Physician Salary Physician Salary Lagged FTE Nurses/Physician FTE Secretaries/Physician Other/Physician Resident Fraction Research/Physician Scale Scale Squared	Average total salary per physician Average total salary per physician the year before Sum of FTE of Nurses per Physcian Sum of FTE of Secretaries per Physician Sum of FTE of Other staff per Physician Sum of FTE Resident per Total FTE Physicians Total Research Points per Physician Number of Beds Number of Beds Squared	Specter and Statistics Norway
Output in DEA analysis	DRG scores	Sum of DRG scores from hospitalization, day treatment and outpatient consultations	National Patient Register
Input variables in DEA analysis	Labour inputs: FTE for each personnel group: Physicians, Nurses, Auxillary nurses, Secretaries and Other staff	FTE estimates based on hours worked including overtime	Specter
	Input prices: Wage cost per FTE in each personnel group	Sum of wage costs including pension and social costs in each group for all FTE, divided by the FTE estimated above.	Statistics Norway
	Non-labour inputs	Total operating costs excluding capital costs minus total wage costs (input price normalised to 1).	Statistics Norway

Furthermore, DRG do not reflect research, education, or several other work duties. Hospitals use a substantial amount of their resources for teaching and research, and such activities may influence both the workload and the efficiency of the institution . Hospital residents need considerable coaching and training, and since this has been reported to influence the productivity of physician staff as a whole and the total workload of senior staff (Farnan, Johnson et al. 2008, Johnson, Shah et al. 2008, Medin, Anthun et al. 2011, McDonnell, Carpenter et al. 2015), we used the balance between residents and senior consultants (Resident fraction) to examine this factor. As a proxy for research, we used the number of publication scores each year for each hospital (Linna, Hakkinen et al. 1998, Bonastre, le Vaillant et al. 2011, Medin, Anthun et al. 2011). These are bibliometric measures of performance which includes the number of journal impact-weighted articles and the number of doctoral theses completed each year. Such data were only available for 2003–2013 and were interpolated for 2001 and 2002 using linear regressions for use in the multivariate analyses.

We included the number of hospital beds (both as a linear and as a quadratic term) to account for scale effects (Aragon 2015). These data were obtained from Statistic Norway. Since the hospitals differed in their scope of emergency capacity, we included fixed effects for each hospital enterprise.

Analytical approach and statistics

We used Farrel's efficiency concepts (Farrel 1957) to define productivity as

Productivity = Output/Input,

where physician technical productivity is measured as the total number of DRG scores per full-time equivalent (FTE) physician. The variables that showed significance in Pearson correlations were included in our multivariate analyses, and our final regressors are listed in Table 1.

The relationship between productivity and salary is a question of cause and effect, as increased salary may stimulate improved productivity, and improved productivity may be rewarded by increased salary. Accordingly, we expect that salary may be an endogenous variable with respect to productivity, whereas personnel mix, research and education are not. In our final analyses, we used the Limited information maximum likelihood (LIML) procedure to account for the simultaneous structure of the salary–productivity relationship with the following simultaneous equations model:

Productivity = a0 + b1*lagSalary + b2 * Other variables

Salary = c0 + d1*lagProductivity + d2 * Other variables,

We constructed three versions of the model. The first model is a time series cross-section model that utilized all available information in the dataset (Model 1). The two other models use fixed effects for hospital, utilizing variation within each hospital over time. In model 2 we assume that there is a 1-year lag in the possible effects of salary on productivity and of productivity on salary, whereas salary from same year is used Model 3.

To further study the physician productivity in relation to the balance of various resources and personnel inputs, we used the non-parametric DEA method to estimate a variable returns to scale cost function (Farrel 1957, Charnes, Cooper et al. 1978, Banker, Charnes et al. 1984). We did not intend to study total factor productivity, but focus on the optimal mix of various personnel groups as revealed by the cost function estimates. We included non-labour costs as described in Table 1.

A cost function is defined as the minimum cost necessary to produce a given level of output (e.g., health services) with exogenously given input prices (e.g., wages). Cost functions assume input substitution possibilities so that the use of an input increases if the wages of that group decrease. The DEA method is basically deterministic, and we used bootstrapping methods to calculate the sampling error of the estimates and assess the variance and confidence intervals (Simar and Wilson 1998, Simar and Wilson 2000). Bootstrapping is a procedure that draws with replacement from the primary data sample, mimicking the data-generating process of the underlying true model, producing multiple pseudo-estimates that allow for the calculation of the sampling error of the estimates and estimate variance, as well as confidence intervals. The assumption is that we know how the data are generated, and we are therefore able to calculate how well our estimates reflect the true costs and efficiency levels, conditional on our data and method. The bootstrapped results are therefore robust with respect to the sampling error, but the bootstrapping procedure does not account for measurement error.

Cost efficiency was decomposed into technical and allocative efficiency (Farrel 1957). High technical efficiency implies that there is no excess input of resources to obtain a certain production level, whereas high allocative efficiency indicates that the mix of input resources is optimized. Allocative efficiency reflects the extent to which the input mix is optimal by comparing the differing marginal costs when the inputs are varied, based on the ratio of prices of the inputs.

We used SAS software version 14 for the panel analysis, the Frisch Nonparametric DEA Program (Frisch Centre, Oslo, Norway), and SPSS (IBM version 22) for the comparison of descriptive data using ANOVA.

Results

Descriptive data

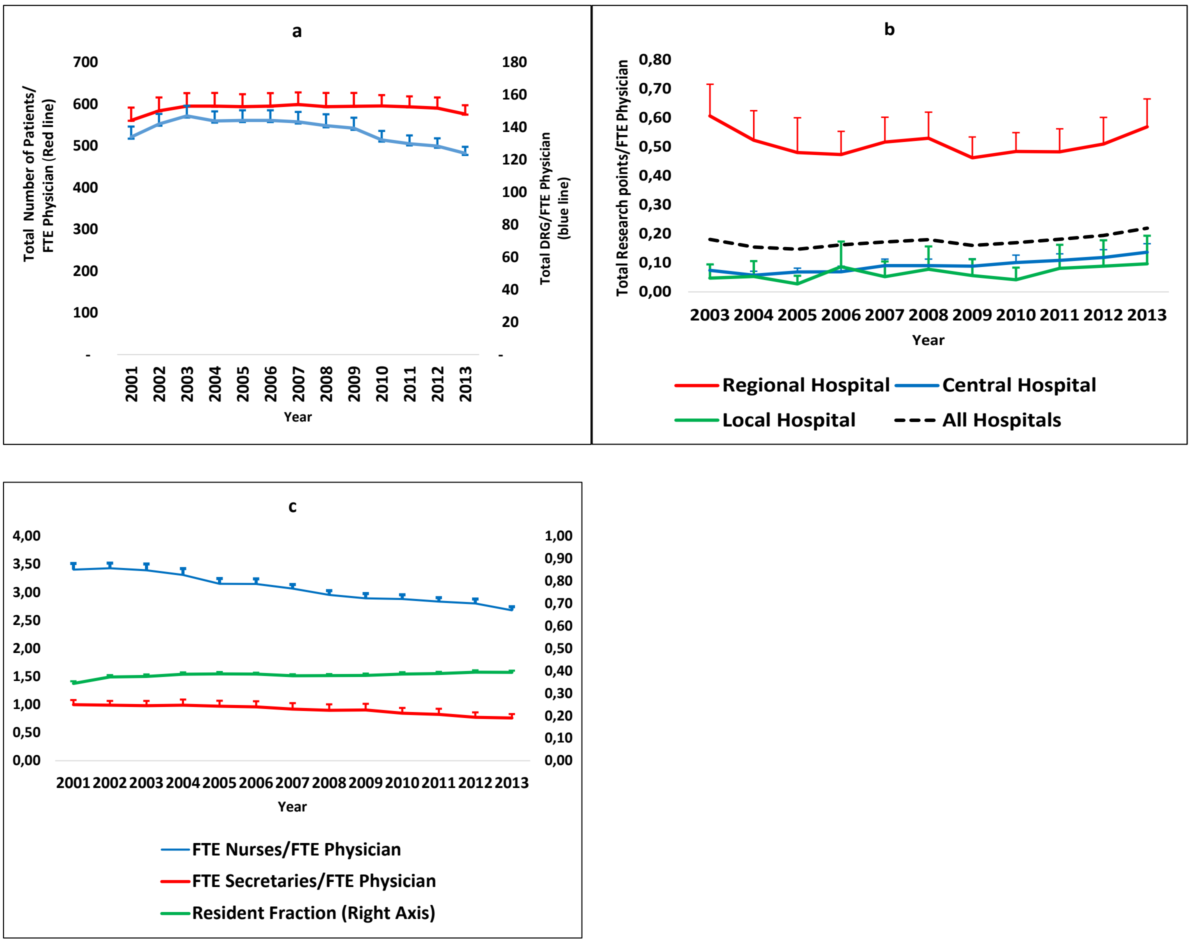
To avoid an extensive table with data from all years, we present descriptive data from 2001 and 2013 (Table 2) supplemented with graphs that illustrate developments over time in some basic variables (Figure 1).

Table 2

	Year							
	2001			2013				
	Sum National Level	Mean of Hospitals	Standard Deviation	Sum National Level	Mean of Hospitals	Standard Deviation	National Change	
Hospital Output								
Hospitalstays	685 901	36 100	21 300	739 191	38 905	21 098	7.8 %	
Daycare treatments	309 112	16 269	11 478	432 376	22 757	13 130	39.9 %	
Outpatient consultations	2 859 315	150 490	98 115	4 510 978	237 420	165 063	57.8 %	
Total number of patient contacts	3 854 328	202 859	130 210	5 682 545	299 081	197 509	47.4 %	
DRG Hospitalstays	698 368	36 756	26 224	951 804	50 095	35 999	36.3 %	
DRG Daycare	98 290	5 173	3 586	92 879	4 888	3 181	-5.5 %	
DRG Outpatient consultations	110 423	5 812	4 595	192 745	10 144	7 299	74.6 %	
Research points (2003 and 2013)	2 596	122	315	3 665	193	396	41.2 %	
Physician variables								
FTE physicians	6 784	357	322	9 852	519	431	45.2 %	
Physician Salary (NOK, Deflated)		671 612	47 078		890 387	45 321	32.6 %	
Productivity	National average	Low/High	Standard Deviation	National average	Low/High	Standard Deviation	National Change	P-val
Hospitalstays / Physician	101.1	62.1 / 158.0	25.2	75.0	44.2 / 105.9	15.7	-26 %	<0.001
Daycare / Physician	45.6	31.6 / 87.2	14.1	43.9	24.6 / 67.8	11.2	-3.7 %	ns
Outpatient consultations / Physician	421.5	280.0 / 703.8	108.8	457.9	341.6 / 602.1	75.5	8.6 %	ns
Total Number of Patient Contacts /	561.1	408.5 / 831.0	112.1	576.8	404.2 / 754.1	96.3	1.4 %	ns
DRG Hospitalstays / Physician	102.9	81.8 / 175.9	21.9	96.6	72.2. / 125.2	16.8	-13 %	<0.05
DRG daycare / Physician	14.5	10.7 / 22.7	3.6	9.4	6.0 / 13.6	2.1	-34 %	<0.001
DRG outpatient consultations / Physician	16.3	11.4 / 20.8	2.4	19.6	13.5 / 26.7	3.4	20 %	<0.001
Total DRG / Physician	134	103.9 / 213.4	24.7	125	91.7 / 163.0	20.2	-6 %	<0.05
Research / Physician (2003 and 2013)	0.36	0.0 / 0.88	0.25	0.37	0.01 / 0.84	0.22	3 %	ns

Figure 1. The development of some parameters 2001-2013.

a. Total patients treated and total DRG scores per FTE physician. b. Research per FTE physician on regional, central and local hospitals. c. Nurses and secretaries per FTE physician and Resident fraction.



The 47 % increase in the total number of patients treated was a consequence of a shift from hospitalized treatment to daycare/outpatient treatment. However, the increase varied from 12% to 92% at individual hospitals. All 19 hospitals reduced the number of hospital beds and six reduced their volume of hospitalizations, while daycare and outpatient treatment increased in all of the studied hospitals, with a magnitude varying from 15% to 92%. For hospitalized patients, the DRG increased more than the number of patients, whereas the opposite was observed for daycare patients. This may reflect a shift of low-intensity treatment from hospitalization to daycare, leaving only the more complex cases in the hospitalized activity.

The total research scores increased by 41% at the national level during our study period, but this development differed considerably across the individual hospitals (Figure 1 b). Regional and university hospitals accounted for 88% of the research activity.

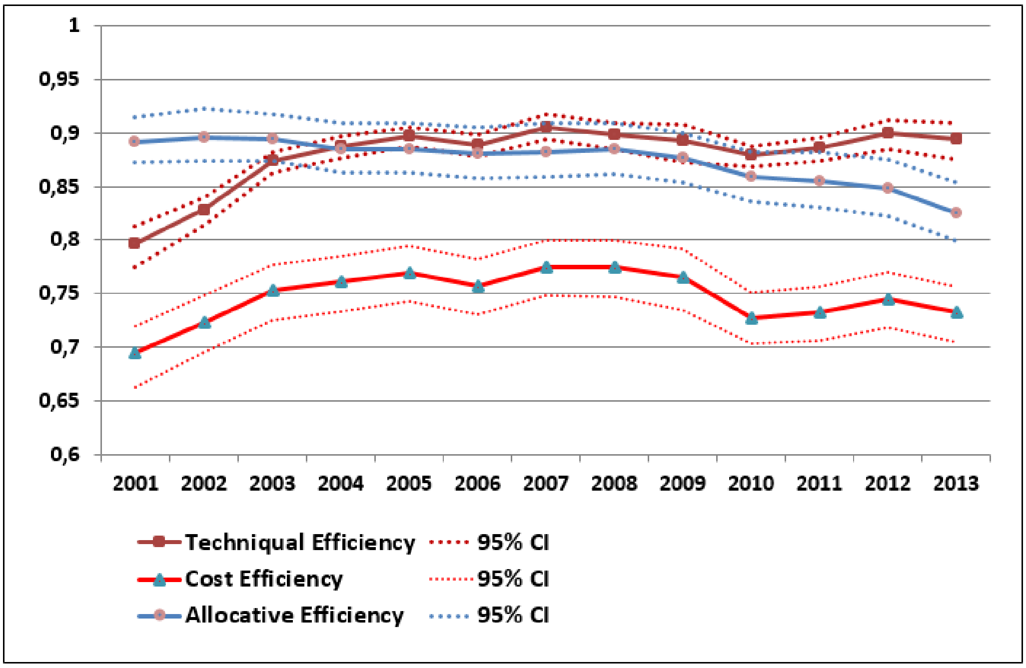
Physician productivity

Table 2 shows that the total DRG scores per FTE physician decreased by 6% ($p < 0.05$) from 2001 to 2013, whereas the total number of patients treated per physician increased by only 1.4 % (26 patients per physician per year, $p = 0.40$). The difference between the hospitals with the highest and lowest DRG per physician decreased from 125% (213 vs. 104) in 2001 to 77% (163 vs. 92) in 2013, but this convergence was mainly caused by a reduction in the high scores and not by an overall increase.

The average research score increased from 0.08 to 0.15 per FTE physician for the central hospitals ($p < 0.01$), but these scores were unchanged for regional and local hospitals (Figure 1 b).

The DEA analysis showed that cost efficiency varied across the study years, but there was no significant upwards or downwards trend. Decomposition revealed that technical efficiency increased during the first four years but levelled off beginning in 2005. A possible interpretation for this finding is that the use of resources was excessive in relation to the patient treatment generated. Allocative efficiency, in contrast, decreased significantly throughout the study period (Figure 2). This indicates that the balance between multiple input resources deteriorated over the study period.

Figure 2. Cost efficiency, technical efficiency, and allocative efficiency 2001-2013. (Bootstrapped averages by year with 95% confidence intervals)



In 2013, technical efficiency was 0.89, and allocative efficiency was 0.83.

Variables potentially influencing physician productivity

The results from the LIML regression models are presented in Table 3.

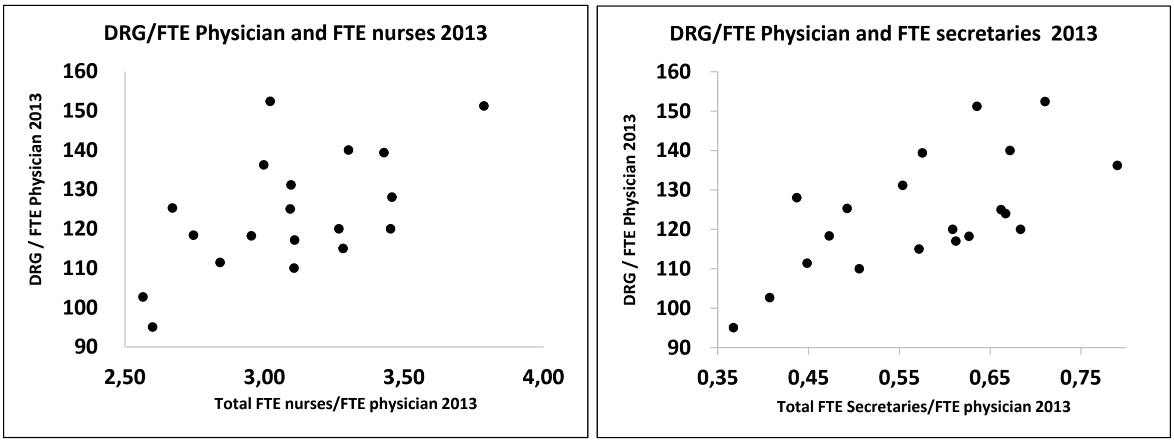
Table 3. Results from LIML analyses.

	Limited-Information Maximum Likelihood Estimation											
	Model 1: Without fixed effect				Model 2: Fixed effect for hospital, salary lagged				Model 3: Fixed effect for hospital, salary sam year			
Parameter	Estimate	Error	t-valu	Pr > |t|	Estimate	Error	t-value	Pr > |t|	Estimate	Error	t-valu	Pr > |t|
Intercept	51.55	42.78	1.21	ns	-70.82	34.00	-2.08	<0.05	-95.26	29.10	-3.27	<0.01
Physician Salary	-0.0004	0.0001	-1.09	ns					0.00004	0.00002	1.95	ns
Physician Salary Lagged	0.0002	0.0003	0.72	ns	0.00006	0.00002	3.02	<0.01				
FTE Nurses/Physician	13.51	3.81	3.54	<.0005	18.02	3.39	5.31	<0.0001	11.51	3.20	3.60	<0.001
FTE Secretaries/Physician	40.51	10.28	3.94	<.0001	47.63	8.89	5.35	<0.0001	41.57	9.40	4.43	<0.0001
Other/Physician	14.57	4.69	3.11	<0.01	10.71	3.46	3.10	<0.01	15.63	3.70	4.22	<0.0001
Resident Fraction	-31.63	40.19	-0.79	ns	89.03	42.08	2.12	<0.05	175.31	39.19	4.47	<0.0001
Reseaarch/Physician	-38.48	11.51	-3.34	<0.01	6.85	16.48	0.42	ns	17.56	17.86	0.98	ns
Scale	0.04	0.01	3.01	<0.01	0.009	0.03	0.32	ns	0.03	0.03	1.24	ns
Scale Squared	-0.0001	0.0000	-2.95	<0.01	0.00005	0	-0.68	ns	-0.00001	0.000007	3.83	ns

The numbers of nurses and secretaries per FTE physician were the strongest correlates of productivity in all analyses, both across and within the hospitals. Figure 3 shows a simple illustration for these relations in 2013, the observations for the other years were similar.

Figure 3

The relation between DRG scores per physician and nurses and secretaries per physician in 2013.



The number of other types of personnel per FTE physician also correlated significantly with productivity. This might be an effect of hospital size, but including this variable as scale and scale squared showed that the scale factor of hospital size converged, with a statistical optimum of approximately 350 beds. A negative effect of higher Resident fraction observed in the univariate analysis was eliminated in Model 1, and residents were shown to have a positive effect on productivity in Models 2 and 3. Also, a negative correlation between the fraction of outpatient consultations and physician productivity in univariate analysis ($r=-0.34$, $p<0.01$) was eliminated in the panel analysis.

Table 4. Bootstrap estimates of optimal costs shares compared to actual observed shares for different resources, 2001 and 2013.

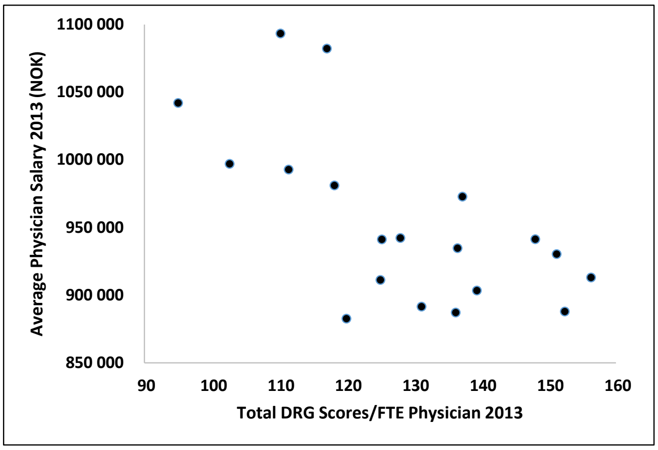
		Quantity (FTEs)	Price in 2013 NOK (Personnel costs)	Cost shares Actual	Optimal	Difference (p-val)	
2001	Physicians	7 108	1 266	14.3 %	15.0 %(14.7%-15.5%)	0,7 %	<0.001
	Nurses	22 032	687	24.1 %	24.2% (23.5%-25.2%)	0,0 %	ns
	Auxiliary Nurses	4 873	611	4.7 %	5.6% (5.1%-6.3%)	0,8 %	<0.001
	Secretaries	6 196	509	5.0 %	4.9% (4.8%-5.9%)	-0,2 %	<0.05
	Nonmedical staff	23 472	608	22.7 %	18.3% (17.4%-18.8%)	-4,4 %	<0.001
	Non-labor inputs	18 240	1 000	29.1 %	32.0% (30.0%-32.9%)	3,0 %	<0.001
2013	Physicians	9 852	1 330	17.1 %	14.6% (14.4%-15.2%)	-2,5 %	<0.001
	Nurses	25 695	729	24.4 %	24.3% (23.6%-25.0%)	-0,1 %	ns
	Auxiliary nurses	3 293	631	2.7 %	5.1% (4.5%-5.8%)	2,4 %	<0.001
	Secretaries	5 242	535	3.7 %	4.8% (4.8%-5.7%)	1,1 %	<0.001
	Nonmedical staff	21 653	672	18.9 %	18.1% (17.5%-19.2%)	-0,9 %	<0.05
	Non-labor inputs	25 535	1 000	33.2 %	33.2% (30.9%-34.0%)	0,0 %	ns

The DEA analysis confirmed the association between physician productivity and personnel mix. However, although the declining allocative efficiency indicates that cost savings could be achieved by changing the input mix, this finding does not reveal which inputs are over- or under-utilized. However, the bootstrapped estimates in Table 4 show that, when comparing the hospitals' actual 2013 cost shares to the "optimal model" based on the bootstrap, the use some inputs was too high and some too low in 2013. Allocative efficiency would be improved if e.g. the use of physicians were decreased so that their cost share was reduced from 17.1% to 14.6% in 2013, while e.g. the cost share of auxiliary nurses should be increased by 2.1%.

Physician remuneration

Physician salary correlated negatively with productivity in the univariate analysis in all years; a simple illustration of this aspect is shown in Figure 4 for 2013. This finding may indicate that hospitals with higher physician salaries are characterized by lower physician productivity than are those with lower salaries. However, this possibility did not reach significance in our Model 1, probably indicating that several factors must be considered to understand the impact of salary levels. The salary from the previous year correlated positively and significantly in the fixed effect model (within hospital analysis), but this was voided by the reciprocal effect of productivity on salary in LIML analysis. In addition to total salary we experimented with different combinations of the various salary elements (regular salary, overtime, on call), but did not obtain significant results.

Figure 4. Univariate relation between physician salary and total DRG scores per FTE physician 2013.



Discussion

The results of the current study show that, although there was a significant increase in treatment activity in Norwegian hospitals from 2001 to 2013, this increase occurred primarily because of the use of more physicians and not because of an improvement in physician productivity. Furthermore, differences across Norwegian hospitals of 80% in the total number of patients treated and 64% in the measures of DRG scores per FTE physician is a challenge with respect to overall productivity and should trigger more research. Our findings correspond well to other reports that have revealed that patient admissions and finished consultant episodes per consultant varied by over 100% between NHS trusts in England (Street and Castelli 2014).

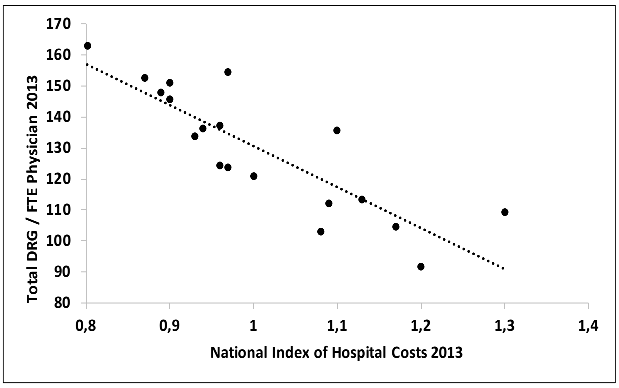
Our most striking result is the strong effect of personnel mix on physician productivity. The LIML analysis revealed that staffing of both nurses and secretaries correlated significantly with productivity, both across and within the studied hospitals. Furthermore, the DEA indicated that, with the current mix of resources, nurse staffing is close to the optimal model, but there is an overuse of physicians of approximately 15% and deficiencies of auxiliary nurses and secretaries of about 89% and 30%, respectively. We interpret this finding as evidence that deelopments occurring during the study period have resulted in a suboptimal personnel mix.

The substantial change from hospitalized to outpatient treatment makes it difficult to fully assess the development of a complex issue such as physician productivity, and this shift in the care level is a factor that may influence our estimates. Such changes may affect both the patient mix and the personnel mix, and it is well known that the lower weight assigned to outpatient activities by the DRG system may underestimate real measures of efficiency (Vitikainen, Linna et al. 2010). However, we find it unlikely that a 26 % reduction in number of hospitalized treatments and a 3.7 % reduction in day treatments per physician may be compensated by an 8.6% increase in outpatient consultations per physician. Of note, several hospitals increased their physician productivity during the period whereas others worsened it. This large variation in the utilization of physician resources among the hospitals observed in our study parallels similar differences presented in previous reports analyzing efficiency at the institutional level of Norwegian hospitals from the same time period (Biorn, Hagen et al. 2003, Biorn 2010). We conclude that the intention to improve personnel productivity has not yet resulted in the homogenous performance of hospitals with respect to the utilization of the physician workforce. This is also consistent with previous reports from other health care systems (Hvenegaard, Street et al. 2009, Castelli, Street et al. 2014, Milstein and Kocher 2014, Street and Castelli 2014, Ineveld, Oostrum et al. 2015). In fact, in their study of Dutch hospitals, Ineveld et al. (Ineveld, Oostrum et al. 2015) found that the difference between the hospitals increased over time.

Although several of the above studies have reported that the overall efficiency of Norwegian hospitals improved in the period we studied, but most of them focused on data until 2004. Without disaggregating such findings, institutional variations in the utilization of core personnel may be missed. We identified a corresponding improvement in cost-efficiency until 2005 but no further improvement thereafter, and found a steady reduction of physician productivity throughout the total period. If efficiency gains are mainly obtained by administrative procedures and reduced staffing in non-medical personnel categories, this may not be a sustainable strategy in the long run (Tiemann and Schreyogg 2012).

DRG scores per FTE physician is a rather coarse measurement, but nevertheless it seems to be fairly well related to the overall costs in Norwegian hospitals (Helsedirektoratet 2013). This is illustrated in Figure 5 for 2013, and similar results were found for all of the years studied. This is an additional indication that physician productivity and, possibly, the corresponding measures for other personnel groups are important in the long-term development of hospital efficiency.

Figure 5



Several studies have documented the effect of personnel supporting physicians on productivity (Grimshaw 2012, Bank and Gage 2015, McDonnell, Carpenter et al. 2015, Rumbold 2015). Several factors may have caused the change in personnel balance that we observed. The shift in care level may change the balance between physicians and other health personnel as daycare and outpatient treatment may require more physicians and less nursing personnel than does hospitalized treatment. Some of the reduction of medical secretary resources observed in our study may be because of the expected effects of technological solutions that are assumed to reduce secretary work (e.g., voice recognition and electronic patient charts). However, studies have reported that a significant increase in non-medical tasks for physicians cast some uncertainty on the effects of such technological strategies (Rosta and Aasland 2014, Rosta 2015). Furthermore, the increasing specialization among physicians may not be reflected to the same extent among nurses.

the effect of resident training on productivity has been extensively studied (Zeidel, Kroboth et al. 2005, Farnan, Johnson et al. 2008, Harvey, Al Shaar et al. 2008, Johnson, Shah et al. 2008, Kawano, Nishiyama et al. 2014). We found a positive correlation between productivity and the fraction of the total FTE of physicians comprising residents. This may reflect the fact that residents in Norwegian hospitals spend a considerable portion of their training time conducting patient treatment.

There are several reports on the effects of incentives for physicians regarding productivity (Conrad, Sales et al. 2002, Andreae and Freed 2003, Wilson, Joiner et al. 2006). The study conducted by Andreae et al. examined the effect of remuneration based on relative value units, finding a 20% increase in clinical productivity with targeted incentives. Such targeted incentives have not been instituted in Norway, and we found little evidence that hospitals with the higher remunerations had doctors that were more productive than their colleagues on hospitals with the lower salaries. One explanation may be that collective bargains still prevail despite local negotiations. The optimal choice of remuneration model should both be related to the actual health care system as well as social and contextual factors (Wranik and Durier-Copp 2011). We definitely believe that such interventions should receive more focus in applied settings, as long as they are based on principles that are ethical and fair for the personnel involved (Pearson, Sabin et al. 1998),

At what level do health care reforms work?

The crucial question facing health care services is whether there will be enough personnel resources to meet future needs, and this question relates especially to physicians. Continued increases in medical specialization will call for more specialized physicians who may restrict their medical scope for patient treatment to their own specialties, which in turn may increase the need for resources.

Policy makers have the intention of improving the efficiency of the health care system through their reforms, and an interesting question may be whether we should expect an effect of political hospital reforms at the bedside (Davis and Rayburn 2016). It is possible that a major part of the effect of political reforms is based on improvements in administrative and organizational perspectives. However, even if reforms may have effects on efficiency at the macro level, we believe that we need political initiatives which also create changes at the micro level, because improvements may not be sustained if they do not include an enhancement of the efficiency of the health care workforce (García-Goñi, Maroto et al. , Conrad, Sales et al. 2002, Franco, Bennett et al. 2002, Drozda and Jr 2013, Ryskina and Bishop 2013, Milstein and Kocher 2014, Burwell 2015, Lieberman and Allen 2015, McWilliams, Chernew et al. 2015, Marshall and Bindman 2016).

In addition to the Norwegian hospital reform in 2001, to other political initiatives had the intention to improve the development. In 2001, all patients were granted free choice of hospitals combined with the removal of county border barriers. This primarily aimed to reduce long waiting times. Recent research has shown that free hospital choice may have reduced the waiting times at the individual patient level, but there is scarce evidence that this change has given reductions at the macro level (Ringard and Hagen 2011). Furthermore, ABF was introduced in 1997, and the percent of ABF financing has been experimented with and changed several times. The intention was to improve efficiency, and previous research has shown that both introduction of ABF as well as expansion of the hospital budgets have been important factors in reducing waiting time for elective patients (Hagen and Kaarboe 2006). Although these two initiatives also may have influenced the hospitals operational performance, we conclude that physician productivity has not improved in the period we studied, irrespective of the political reforms.

Norway, like several other modern health care systems, will face a significant deficit of health personnel in the future (Roksvaag and Texmon 2012). For this reason, we believe that there must be a considerably stronger focus on improving workforce productivity at the clinical level. Our data strongly indicate that staffing and personnel mix significantly influences the utilization of health personnel. Accordingly, any reform or change should also stimulate the core personnel, and managerial and organizational efforts, leadership, and economical incentives ought to focus on such goals.

The large differences in physician productivity observed across the hospitals in our study may indicate a considerable potential for improvement. Optimizing hospital staff is essential for improving efficiency, because personnel costs constitute more than 60% of total expenses. Several factors such as leadership, the improvement of occupational health, and the reduction of temporary staff and overtime may contribute to this optimization. In an interview-based study of managers and clinicians in orthopedics and cardiology in acute hospitals, Bloom et al. (Bloom, Propper et al. 2015) concluded that management quality was favorably correlated with indicators of hospital performance with respect to waiting times, mortality, financial performance, and staff satisfaction. Burns and Muller (Burns and Muller 2008) also focused on such factors in their review of literature on hospital/physician collaboration. They found that the characteristic distinguishing between high- and lowperforming hospitals was “the level of both hospital executive and physician behavioral skills,” including physicians’ trust in hospital executives, mutual respect and support, communication, physicians’ involvement in clinically related decision making, and hospital executive leadership over time. This finding likely supports the idea that future reforms should promote a united process with professional medical development and system reforms.

Limitations

The productivity measures used in the present study have limitations. None of the parameters covers the activity in a complete manner individually, and the extent to which their combination may compensate for this limitation is unclear. As our data have shown, despite an increase in the number of patients treated, the DRG scores did not increase to the same extent. The DRG measures have been adjusted over the study period because of economic considerations, and, although these measures may be adequate within each year, comparisons over time may be distorted. Nevertheless, DRG measures are the standard official way of measuring treatment activity for annual governmental reports that assess productivity in Norwegian hospitals today.

With an increasing population of chronically ill patients, there may be a shift towards more control and follow-up activities in hospitals. Some of this activity may require full-scale personnel resources without triggering full DRG reimbursement as would be the case with new patients. In addition, the differing combinations of medical activities among the studied hospitals may have caused unequal scores on the variables we have used. We cannot rule out the possibility that assessing more specific characteristics of hospitals could have given different results.

Conclusions

Despite several political reforms of the Norwegian hospital sector in the period we studied, physician productivity as assessed by our measures declined over the study period, and we found significant variation in productivity among Norwegian hospitals. These findings must be addressed further by future work if the coming challenges are to be solved. It is obvious that the balance between support staff and the physician workforce may have a significant effect on the utilization of physicians, and the current situation in our data indicates that future planning regarding support staff should have a factual and rational basis. Because there is a great deal of variety in the individual competence and performance of health personnel from clinical, educational, and scientific perspectives, we believe that more individual incentives and less collective solutions should be considered when future remunerations are negotiated.

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