Received: 15 September 2020 | Revised: 25 June 2021 | Accepted: 29 June 2021

DOI: 10.1002/hec.4391

RESEARCH ARTICLE

Health Economics WILEY

Have Dutch Hospitals Saved Lives and Reduced Costs? A longitudinal patient-level analysis over the years 2013–2017

Sandra Sülz[1] | **Holger Wagenaar**[2] | **Joris van de Klundert**[1,3]

[1]Erasmus School of Health Policy & Management, Rotterdam, The Netherlands

[2]Performation, Bilthoven, The Netherlands

[3]Prince Mohammad bin Salman College of Business & Entrepreneurship, King Abdullah Economic City, Saudi Arabia

Correspondence
Sandra Sülz, Erasmus School of Health Policy & Management, Postbus 1738, Rotterdam, 3000 DR, The Netherlands.
Email: sulz@eshpm.eur.nl

Abstract

The purpose of this paper is to shed light on the ongoing Dutch health system reforms and identify whether hospital costs and hospital outcomes have changed over time. We present an empirical analysis that is based on granular micro-costing data and focuses on conditions for which mortality is indicative of outcome quality, that is, acute myocardial infarction (AMI), chronic heart failure (CHF), and pneumonia (PNE). We deploy a dataset of more than 80,000 inpatient episodes over 5 years (2013–2017) to estimate regression models that control for variation between patients and hospitals. We have three main findings. First, our results do not indicate significant outcome improvements over the years; that is, there is no time trend for mortality. Second, there is heterogeneity in cost developments: for patients who survive their inpatient stay, our data indicate that costs *increase* significantly by 0.9% per year for AMI patients, while costs *decrease* significantly by 1.7% per year for CHF patients and by 1.9% per year for PNE patients. For patients who pass away during their inpatient stay, our data do not indicate significant time trends. Third and finally, our results suggest the existence of substantial cost variation between hospitals.

KEYWORDS
empirical analysis, hospital costs, hospital outcomes, micro-costing

1 | INTRODUCTION

Many countries across the globe have designed and implemented health system reforms with the joint purposes of improving outcomes and reducing costs. These two components form the numerator and denominator of cost-effectiveness and are the ultimate measure of value-based health care (Drummond et al., 2015; Porter, 2010). The core of these objectives can be condensed to reducing the burden of cost and lives cut short (World Health Organization [WHO], 2018). This study sheds light on the improvements in the commonly reported measures hospital costs and hospital mortality in the Netherlands for the conditions, acute myocardial infarction (AMI), chronic heart failure (CHF), and pneumonia (PNE). It considers the period 2013–2017 after the Dutch Health Reform has completed its gradual implementation in 2012 (Douven et al., 2020; Schut & van de Ven, 2011)

In 2006, the Dutch health authorities introduced market factors into the health system and gradually transformed health care into a system of managed competition on three markets: the market between patients and hospitals, the market between insurers and hospitals, and the market between patients and insurers (Schut & van de Ven, 2011). The reforms envisioned insurers to promote access, efficiency, and quality of hospital care, in alignment with patient preferences (Douven et al., 2020; Schut & van de Ven, 2011). One component of the reform was introducing the possibility for Dutch health insurers to freely negotiate prices with hospitals. More specifically, insurers are expected to select and contract hospitals with better prices and quality (Krabbe-Alkemade et al., 2017). While the share of freely negotiable DOTs (diagnosis-treatment combinations, the Dutch form of diagnosis-related groups)[1] amounted to approximately 10% of hospital revenue in 2005, it gradually increased to 20% in 2008, 34% in 2009, and 70% in 2012 (Schut & van de Ven, 2011; Roos et al., 2020). Thus, hospitals are incentivized to reduce cost and hospital mortality, as considered in this study.

The effectiveness of the Dutch reform continues to be disputed (Douven et al., 2020; Krabbe-Alkemade et al., 2017). Roos et al. (2020), for instance, focus on the period 2001 through 2010 and did not find negative implications of price deregulation on quality (operationalized with hip-replacement readmission rates). Krabbe-Alkemade et al. (2017) find that total hospital costs decreased as market competition increased between 2005 and 2009. van Ineveld et al. (2016), however, find that quality-adjusted hospital productivity decreased over the same period.

Our study focuses on the time frame 2013 through 2017, that is, a time period substantially after the first elements of the health reform were put in place. Hence, our time frame does not coincide with the initial reform years but instead coincides mostly with the implementation of reforms initiated in 2012. 2012 was, for instance, the year of transitioning from Diagnose Behandeling Combinatie (DBCs) to DOTs and of the introduction of a nationwide constraint on total hospital costs. Moreover, while selective contracting has indeed been possible since 2006, it has only gained momentum since 2010 (Roos et al., 2020; van Ineveld et al., 2018).

Our study sheds light on the effectiveness of the reform after the initial implementation stage by regarding the prime outcome measures, hospital costs and hospital mortality. As a worst possible outcome, the quality indicator (in-hospital) mortality has been commonly reported for AMI (Chin et al., 2011), CHF (Peterson et al., 2010), and PNE (Marrie & Wu, 2005), specifically in relation to cost (Chen et al., 2010; Häkkinen et al., 2014, 2015; Romley et al., 2015). While hospital cost measurement seems as straightforward to measure as mortality, measurement of hospital costs has posed many challenges for researchers, thus complicating cost-effectiveness analysis and reform evaluation (Drummond et al., 2015; Jacobs & Barnett, 2017; Kaplan & Porter, 2011; Tan et al., 2009). Detailed costing approaches, such as bottom-up micro-costing and (time driven) activity-based costing, have been argued to be the gold standard that reflects "true cost" most accurately, yet such approaches are costly and cumbersome to systematically deploy (Jacobs & Barnett, 2017; Kaplan & Porter, 2011; Tan et al., 2009). Unfortunately, however, more convenient alternatives have been shown to differ substantially from bottom-up micro-costing, both for average costs and individual patient-level costs (Chapko et al., 2009, Mercier & Naro, 2014; Tan et al., 2009). For AMI, for instance, gross costing methods gave cost estimates that were 103% higher than bottom-up cost estimates (Tan et al., 2009). Consequently, bottom-up micro-costing approaches have, therefore, been recommended for conditions that contribute considerably to hospital costs—as can be argued to be the case for AMI, CHF and PNE—and when patient level data are considered (Tan et al., 2009; Kaplan & Porter, 2011; Jacobs & Barnett, 2017). For the Netherlands, the use of charges as a proxy for cost, as practiced in a closely related study on cost and mortality for AMI, HF, and PNE in the United States (Romley et al., 2015), is explicitly discouraged by the Dutch guidelines for economic evaluation in health care (Hakkaart-van Roijen et al., 2015).

To advance insight on the development of costs and outcomes after the gradual implementation of the Dutch health reform, this study presents a patient-level analysis using data from 84,970 patient episodes in 32 hospitals over the 5 years, 2013 and 2017 for AMI, CHF, and PNE. It uses patient-level cost data obtained through bottom-up micro-costing and patient-level mortality data. If Dutch hospitals were able to increasingly save lives and costs in the post-reform years, we would expect mortality rates to decline over the years and costs to decrease; the latter, in particular, for patients with low mortality risks who survived the hospital stay. For the sub-sample of patients with high risk of dying, one may expect costs to vary. For some patients, survival may require providing more care and thus higher costs. Other patients may pass away early on and therefore limited costs accrue. The patient-level data allow us to separate the analysis for surviving and non-surviving patients allowing for insights in cost time trends that hospital-level data cannot provide.

2 | RESEARCH METHODS

2.1 | Data collection

In 2017, 74 hospitals existed in the Netherlands (Dutch Hospital Association, 2018). Among these 74 hospitals are 8 tertiary university hospitals whose patient populations and cost structures differ substantially from those of the 66 general hospitals. Of the general hospitals, 53 have enrolled in the hospital benchmarking services of the company Performation for at least one of the years between 2013 and 2017. All data are collected from the standardized data hospitals have provided for these benchmarking purposes, for which they have given consent that data can be used for research purposes while maintaining the anonymity of patients and hospitals. Hence, only access to anonymous patient and hospital data has been granted, and only within the facilities of Performation. This study was outside the scope of the Netherland's Medical Research Involving Human Subjects Act and therefore did not require formal ethical approval.

The cost data and allocation methods are provided below in a separate subsection. We first describe the data for mortality and control variables.

Individual patient data collected from the benchmarking data include age, gender, reason for admission (diagnosis codes), a set of variables representing long-term care conditions, and socioeconomic condition, as well as whether the patient passed away during the hospital stay. Our three conditions are identified by means of the ICD-10 diagnosis codes (AMI: I21, CHF: I05-09, PNE: J09-18). To limit patient-age heterogeneity, we restrict our observations to patients aged 65 years and older. Following systematic review findings (Sharabiani et al., 2012), we control for long-term care conditions such as the Elixhauser comorbidity index and let the component weights be set by the regression model rather than calculating a weighted score using a priori weights. Some adjustments to component definitions have been required because of data availability (see Appendix). To approximate the patients' socio-economic status (SES), we incorporate a categorial variable ranging from 1 (highest SES) to 9 (lowest SES). The SES information is taken from the Netherlands Institute for Social Research (Sociaal en Cultureel Planbureau), which ranks geographic areas based on the SES information of the residents. Based on the patient's ZIP code, each patient is then assigned the SES category of her place of residence.

2.2 | Costing methods

For each anonymous hospital and patient admitted, costing data are considered per care activity provided as described in Performation (2020) and outlined below. Adopting standard cost accounting terminology, the care activities form the cost objects. This logic is inherited from national guidelines and models to calculate average unit costs for care activities and cost prices for DOTs (Hakkaart-van Roijen et al., 2015; Oostenbrink & Rutten, 2006) as applied in various studies on AMI, CHF, and PNE (Halbersma et al., 2011; Soekhlal et al., 2013; Vissink et al., 2016). The patient-specific cost per DOT (as opposed to the average cost) is subsequently calculated as the sum of the costs of the care activities for the hospital in which those activities are delivered to the patient. The cost amount of a cost object may be identical for all patients receiving the same care activity, for example, in the case of a lab test, or may be patient dependent, for example, in the case of surgery, as the cost of the operating theater is calculated per minute used. Whereas hospitals can allocate costs using their own cost objects and codes, 99.5% of the costs included in the analyzed dataset are allocated to nationally standardized codes.

The costs per care activity are calculated using a full costing approach that includes all costs of general ledger accounts associated with providing care. Costs for overhead departments (support centers) are allocated to medical departments (mission centers) using a direct allocation method for which all hospitals use the same allocation bases. Within medical departments, indirect costs are again allocated to cost objects using a variety of standardized, uniformly applied allocation bases. While time plays an important role as an allocation base, other allocation bases are also used, and indirect costs and overhead costs are not defined in terms of activities (Kaplan & Porter, 2011). Altogether, the direct costs are calculated using a bottom-up micro-costing approach, while overhead costs and indirect costs are allocated in a top-down fashion (Jacobs & Barnett, 2017; Tan et al., 2009).

2.3 | Sample construction

The above-defined costing data for sampled patients for the three conditions, AMI, CHF, and PNE, are available for the period 2009–2018. In total, the data contain the costs of 1,626,292 care activity units in 47 hospitals. Costs are calculat-

ed using the 2017 inclusion and allocation guidelines (Performation, 2020). Our interest is to identify the trend in cost development that is due to different treatment profiles and different activities conducted during the patient's inpatient episode, that is, we are not interested in cost development due to price inflation. Therefore, we use a fixed reference year (2017) and determine the cost per unit (e.g., costs per inpatient day) for each care activity in 2017. We then recalculate the DOT costs of all other years by evaluating the activities with the unit costs from 2017. We first exclude 36 care activity units with negative costs and 1262 care activity units that cannot be matched to a unique patient identifier. This leaves us with the costs of 1,624,994 care activity units for 306,237 patient episodes in 47 hospitals. Hospitals that have engaged in mergers (or acquisitions) with other hospitals were eliminated to avoid costs being impacted by balance sheet corrections, provisions, costs of M&A activities, etc. ($N = 46{,}253$ patient episodes). We further exclude outpatient episodes ($N = 145{,}068$ patient episodes).

For each hospital participating in the benchmarking program, the data from the first year of participation is excluded ($N = 10{,}316$ patient episodes) because of partial reporting in the first year and possible initial reporting errors. In case of discontinuing participation in the benchmarking program, the last year is also excluded ($N = 9618$ patient episodes). By excluding the first and last years of data entry, we ensure that the full annual costs for each hospital-year are considered. Moreover, per hospital, we exclude all years of data for which the cost for an inpatient day was below €200 or above €1000 to mitigate the influence of outliers and data reporting errors ($N = 138$ patient episodes). For the same reason, we exclude observations at the hospital-condition level if the average annual costs across patients were larger than €100,000 ($N = 407$ patient episodes). We further exclude observations at the hospital-condition level if the total annual costs change by more than 50% relative to the subsequent period ($N = 2776$ patient episodes).

After this data cleaning procedure, 91,661 patient episodes from 32 hospitals from 2011 to 2017 remained. The sample is unevenly distributed over the years, with 2.4% of the patient episodes starting in 2011, 4.9% in 2012, 13.8% in 2013, 17.1% in 2014, 23.2% in 2015, 21.3% in 2016, and the residual 17.3% in 2017. Because of the small number of patient episodes in 2011 and 2012 and the system-wide transitions from DBCs to DOTs in 2012, the years 2011 and 2012 were excluded. The final sample consists of 84,970 patient episodes in 32 hospitals between 2013 and 2017. The included hospitals likely provide a representative sample of general Dutch hospitals (see Appendix for details).

2.4 | Model specification

For each of the three conditions, we first model mortality over the years 2013–2017. For mortality, we estimate the patient's latent health status D^*_{iht} as follows:

$$D^*_{iht} = \beta_0 + \beta_1\, time\,trend_t + \beta_2\, X_{i,h,t} + \beta_3\, H_h + \varepsilon_{i,h,t}$$

$$D_{iht} = 1\left[D^*_{iht} > 0\right]$$

where the binary variable D_{iht} is equal to 1 if the patient died during the hospital episode and is 0 otherwise. Our independent variable is $time\,trend_t$ and we rely on a linear specification with the baseline year 2013 = 0. A negative coefficient β_1 then reflects a decline in mortality. The vector $X_{i,h,t}$ contains patient demographics (gender, age, age squared), dummy variables for each long-term condition the patient is suffering from (Yes = 1, 0 otherwise), and dummy variables for a number of socioeconomic states (SES category 1: Yes = 1, 0 otherwise; likewise for SES categories 2–9). H_h denotes the vector of hospital fixed effects, and $\varepsilon_{i,h,t}$ indicates the idiosyncratic errors. Assuming that the error terms $\varepsilon_{i,h,t}$ are independently sampled from a standard normal distribution allows us to estimate a probit model for each condition to identify any significant time trend in mortality.

Subsequently, we split the population of included patients into two subpopulations, a subpopulation of patients who survived the hospital episode and a subpopulation of patients who died during the episode. For each of the three conditions and each subpopulation, we estimated the development of costs over the years 2013–2017 using the following model:

$$Ln\left(Cost_{i,h,t}\right) = \beta_0 + \beta_1\, time\,trend_t + \beta_2\, X_{i,h,t} + \beta_3\, H_h + \varepsilon_{i,h,t}$$

Estimating the cost development separately for surviving patients and deceased patients allows us to identify diverging cost trends among these subpopulations.

3 | RESULTS

3.1 | Descriptive overview

Figure 1 outlines the unadjusted inpatient mortality rates over the years. For AMI, mortality dropped from 7.6% in 2013 to 5.1% in 2017; for CHF, mortality dropped from 13.8% in 2013 to 11.4% in 2017; and for PNE, mortality declined from 20.0% in 2013 to 15.5% in 2017. However, as indicated in Figure 1, inpatient mortality rates seem to vary stochastically.

Figure 2 depicts the development of costs over the years for the subpopulation of patients who have survived the inpatient episode and for the subpopulation of patients who have not survived the inpatient episode. For patients surviving the hospital episode, uncontrolled average annual costs increased from €5403 (SD: 5718) in 2013 to €6151 (SD: 4727) in 2017 for AMI. For CHF, the increase is from €6582 (SD: 9358) in 2013 to €7060 (SD: 9729) in 2017. For PNE, the uncontrolled average annual costs decline from €6601 (SD: 11,985) in 2013 to €5764 (SD: 7460) in 2017.

For patients who passed away during the hospital episode, we observe similar patterns in uncontrolled average costs: an increase from €5642 (SD: 9217) in 2013 to €7827 (SD: 12,981) in 2017 for AMI; for CHF, an increase from €5730 (SD: 10,943) in 2013 to €6661 (SD: 8113) in 2017; and a decrease for PNE from €7871 (SD: 12,110) in 2013 to €6841 (SD: 8868) in 2017.

While absolute cost levels and trends are comparable between the two subpopulations, Figure 2 illustrates that the uncertainty in the annual estimate is far higher for the subpopulation of deceased patients. This uncertainty may be caused by a smaller population size and by larger variation in the care activities provided.

3.2 | Model results

We now present the mortality and cost development results that include controls for variation between patients and hospitals. Table 1 presents the mortality models in columns 2–4, the cost models for non-deceased patients in columns 5–7, and the cost models for deceased patients in columns 8–10 (a full overview of the coefficients is provided in the Appendix).

Concerning the mortality models, we see that there is no strong indication of a decreasing or increasing annual trend in mortality; all probit coefficients are insignificant. In line with what we have already observed in the descriptive overview, once patient demographics and the substantial variation between hospitals is taken into account, the results of our analysis find no significant trend in mortality rates for AMI, CHF or PNE over the period 2013–2017.

Concerning cost development, we observe the following: for AMI patients, there is a very significant annual cost increase of 0.9% (95% CI: [0.2%; 1.6%]) for surviving patients and a non-significant decrease of 0.1% (95% CI: [-4.0%; 3.8%]) for deceased patients. For surviving CHF patients, annual costs decrease significantly by 1.7% on average (95% CI: [−3.0%; −0.4%]), whereas costs increase non-significantly by 1.1% (95% CI: [−2.5%; 4.6%]) on average per year for deceased CHF patients. For PNE patients, the average annual costs decline very significantly by 1.9% (95% CI: [−2.7%; −1.1%]) for surviving patients and fall by a non-significant 1.7% (95% CI: [−3.7%; 0.4%]) for deceased patients.

Our results indicate substantial cost variation between hospitals. The coefficients of the hospital fixed effects represent the average deviation of a focal hospital from the hospital that is selected as a reference category. To make a meaningful comparison that is independent of the chosen reference category, we generate a fictitious benchmark equal to the hospital fixed effect averaged over all hospitals in the sample. For each hospital in the sample, we then calculate the deviation between the hospital fixed effect and the benchmark. A value of 0.5 (−0.5) indicates that a hospital's patient costs are on average 50% higher (lower) than those of the sample benchmark. We compare the between-hospital variation in terms of costs for non-deceased patients with the variation for deceased patients (Figure 3a,c,e). Hospitals with higher costs for non-deceased patients thus tend to have higher costs for deceased patients as well. We subsequently explore whether hospitals with higher mortality rates are the ones with higher (or lower) costs than average. To avoid that this comparison is distorted due to case-mix differences, we predict mortality rates averaged over all years for the counterfactual scenario that all hospitals admit the same "reference" sample patient.[2] We contrast these predictions with the cost deviations for non-deceased patients (Figure 3b,d,f). These results indicate that hospitals with lower costs for non-deceased patients do not have higher mortality rates. We obtain similar results for the costs deviations for deceased patients (results provided in Appendix) suggesting that hospitals with lower costs for deceased patients do not have higher mortality rates either.

In terms of the costing models, we see that the explained variance is rather low, and the highest R^2 is 0.238 for non-deceased AMI patients. Since we are interested in identifying the time trend rather than setting up prediction models, the

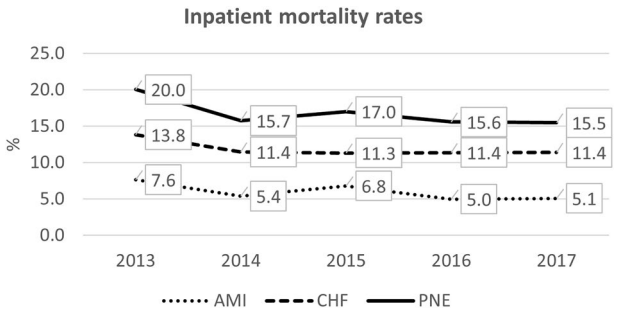

FIGURE 1 Outcome development—unadjusted mortality during in-hospital stays

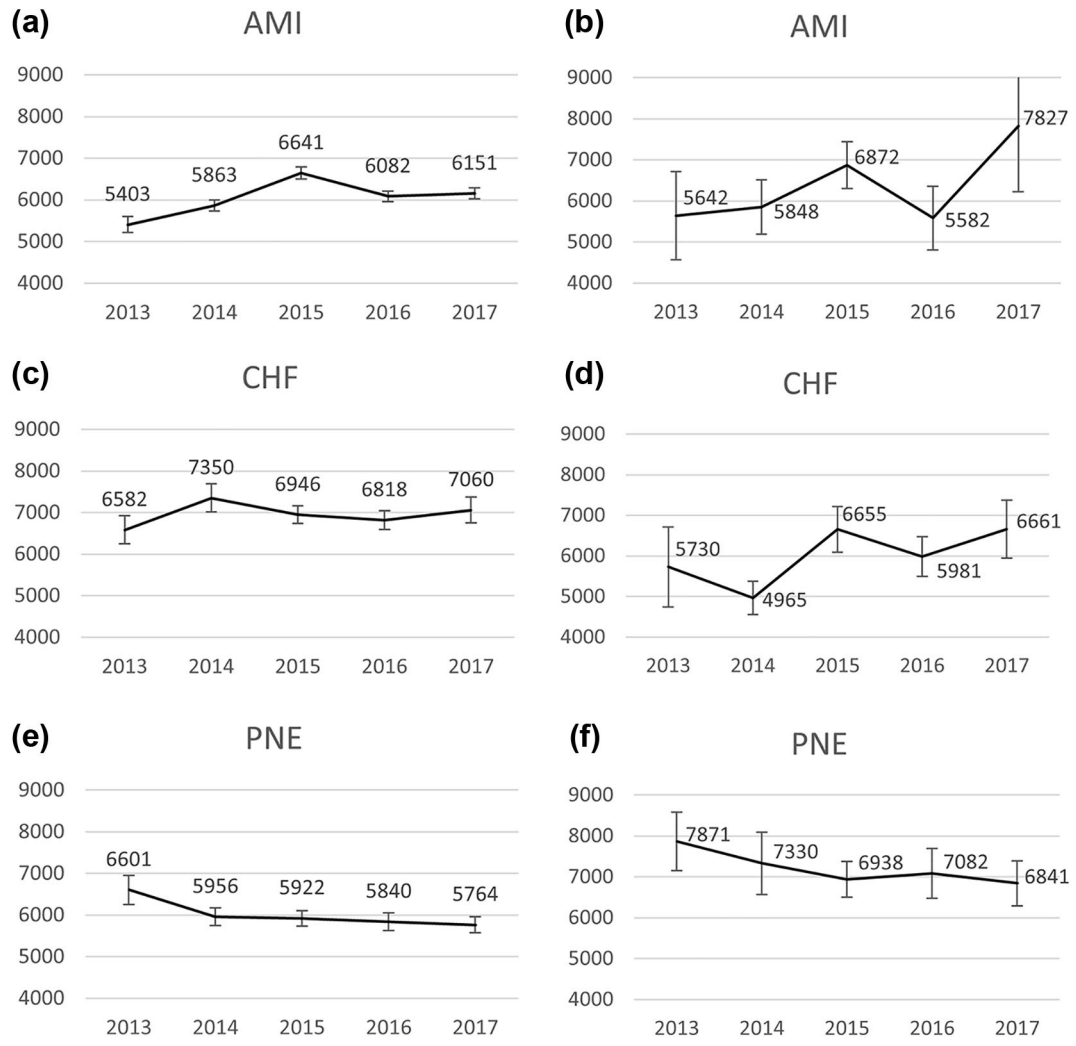

FIGURE 2 Cost development—average annual costs in € including 95% CI for non-deceased patients (a, c, e) and deceased patients (b, d, f)

fact that the explained variance is rather low does not pose a problem as long as the relevant confounders have been incorporated into the model. Time-invariant differences between hospitals are accounted for by hospital fixed effects, and we address substantial sociodemographic and comorbidity differences between patients. Despite this, patients can still differ in factors that remain unobserved by the researcher. We will discuss in the next section whether and how this might have impacted our results.

TABLE 1 Outcome development—Estimating inpatient mortality and cost development over the period 2013–2017

	Probit coefficients			OLS coefficients ln(costs of inpatient stay)					
	Mortality			Non-deceased patients			Deceased patients		
Variables	**AMI**	**CHF**	**PNE**	**AMI**	**CHF**	**PNE**	**AMI**	**CHF**	**PNE**
Linear time trend	−0.004	0.009	−0.004	0.009**	−0.017*	−0.019***	−0.001	0.011	−0.017
	(0.013)	(0.011)	(0.008)	(0.003)	(0.007)	(0.004)	(0.020)	(0.018)	(0.011)
Male	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.
Age, age^2	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.
Long-term care conditions	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.
Socioeconomic status	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.
Hospital fixed effects	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.	incl.
Observations	16,239	12,650	25,173	23,504	16,073	26,827	1463	2371	5423
R^2	NA	NA	NA	0.238	0.178	0.071	0.172	0.113	0.079

Notes: Robust standard errors in parentheses. Number of observations varies due to perfect prediction and missing values for some of the control variables.
***$p < 0.001$ **$p < 0.01$ * <0.05.

4 | DISCUSSION AND CONCLUSION

4.1 | Principal findings

The purpose of this paper is to shed light on the ongoing Dutch health reforms and identify whether hospital costs and hospital outcomes have changed between 2013 and 2017. We present an empirical analysis that is based on granular micro-costing data and focus on conditions for which mortality is indicative of outcome quality. We find no indications of quality differences over the years and a heterogeneous picture in terms of cost developments. For patients who survive their inpatient stay, our data indicate that costs *increase* significantly by 0.9% per year for AMI patients and that costs *decrease* significantly by 1.7% per year for CHF patients and by 1.9% per year for PNE patients. For patients who pass away during their inpatient stay, our data do not indicate significant time trends. Taken together, our results support the proposition that the Dutch health system reforms have not saved lives or reduced costs.

One explanation for the heterogeneity in cost development lies in the fact that the conditions themselves are quite different from each other. Whereas AMI has an acute onset and might require technology-dependent invasive treatment (Soekhlal et al., 2013), CHF is a chronic disease in which the therapeutic emphasis is less on technology but more on prevention and avoiding (re-) hospitalizations (Ponikowski et al., 2016). In the Netherlands, there has also been an increasing presence of automatic external defibrillators in public locations that could affect the state in which AMI patients arrive at the hospital (Blom et al., 2014). In the case of PNE, the disease could either be a community-acquired case present upon the patient's admission or could be a nosocomial infection the patient develops during hospitalization for a different reason. Other studies conducted in the Dutch setting, albeit with different methodologies and different time frames, also suggest substantial variation in hospital costs between conditions (Halbersma et al., 2011; Rozenbaum et al., 2015; Soekhlal et al., 2013; Tan et al., 2009; Vissink et al., 2016).

Our study complements various studies that sought to evaluate the effectiveness of the Dutch health reform. While previous research focused on the first years after implementation up until 2010 (Krabbe-Alkemade et al., 2017; Roos et al., 2020; van Ineveld et al., 2016), we focused on the time frame 2013 through 2017, that is, a time period substantially after the first elements of the health reform were put in place and coinciding mostly with the implementation of reforms initiated in 2012. Our results can thus be interpreted as providing evidence that these second-round reforms have not reduced costs or saved lives. At the same time, the considerable variation among hospitals strongly suggests that cost improvements were attainable for many hospitals and did not come at the expense of higher mortality rates.

4.2 | Limitations

Although our results indicate that the patient mix does not change over time (see Appendix), we most likely do not capture patient severity in its completeness. This could have implications for our mortality models that currently do not

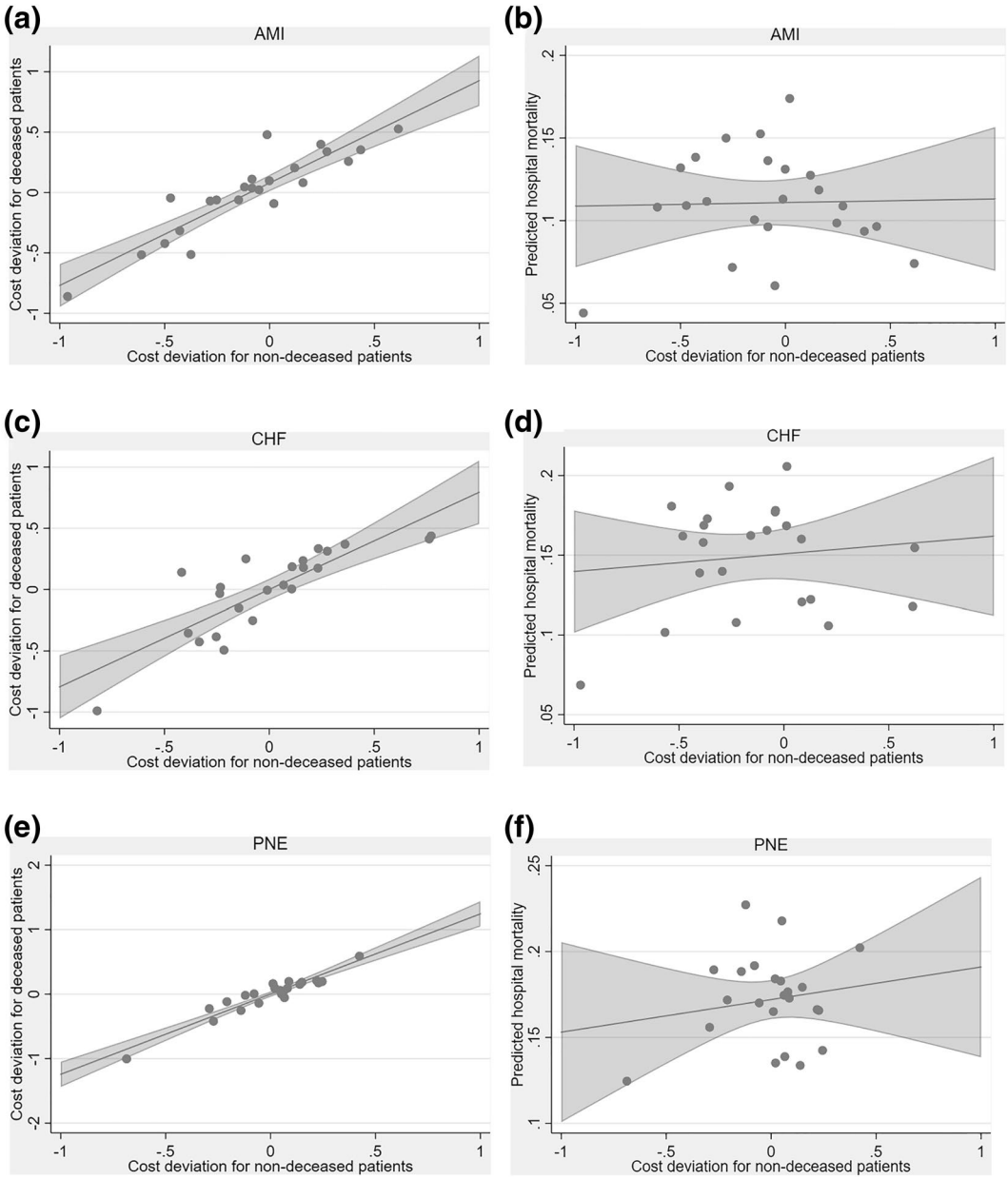

FIGURE 3 Relationship between the costs of non-deceased versus deceased patients (a, c, e) and costs of non-deceased patients versus predicted hospital mortality (b, d, f). The scatter plots show the observed data points at hospital-level and the shaded area indicates the 95% CI of the estimated relationship obtained from regressing the cost deviation for deceased patients (predicted hospital mortality) on the cost deviation for non-deceased patients

identify a trend over time. If unaccounted patient severity increased (decreased) over the years and hospitals simultaneously increased (decreased) service quality, these two effects would cancel each other out, and the outcome effects would remain unobserved.

Choosing mortality as an outcome might invite the criticism that it is a one-dimensional measure and cannot differentiate further among patients in the same outcome category. Patients might still experience differences in quality of care even though all of them are survivors (or non-survivors), and by focusing on mortality only, we neglect these nuances. Quality of care is an inherently debatable concept, and there are different views on how to conceptualize and operationalize it (Song & Veeraraghavan, 2018; Wiig et al., 2014). The set of quality indicators reported by hospitals varies among hospitals and over the years, and the definitions of the indicators change. Relying on the straightforward measure of mortality avoids the complexities of reconciling these quality measurement difficulties. We consequently focused on conditions for which mortality has indeed been associated with deficiencies in quality of care (Agency for Healthcare Research and Quality, 2006).

4.3 | Implications

Motivated by the ongoing health system reforms to stimulate value-based health care, we aimed to determine how hospital costs and mortality have developed over the years 2013–2017 for AMI, CHF, and PNE in the Netherlands. Based on granular and contemporary patient-level data, we conclude that there has been no change in quality over the years, that is, hospitals did not improve over the years but rather seem to have maintained the same level of quality. For two out of three conditions, this has coincided with a decrease in costs and indicated that hospitals, on average, were able to increase value over the years. For one condition (AMI), however, maintaining the same service level seems to have required more spending, as indicated by increasing costs. Our results, therefore, cast doubt on the effectiveness of the health system reform measures implemented in the Netherlands. At the same time, our results are also of interest to practitioners because the substantial differences in costs between the hospitals indicate potential for value improvement. Policy-makers and hospital management are encouraged to advance their understanding of cost drivers and cost differences and to find measures to reap the benefits of possible cost reductions without negatively impacting mortality.

ACKNOWLEDGMENT

The authors are grateful for valuable discussions with Justin M. Bachmann, Melinda J. Buntin, Hilco J. van Elten, Steven Lugard, and John Romley.

CONFLICT OF INTEREST

Sandra Sülz and Joris van de Klundert report no conflict of interests. Holger Wagenaar reports being principal consultant at Performation, the privately owned company that provides benchmarking services to hospitals and whose data are used in this study.

ORCID

Sandra Sülz https://orcid.org/0000-0002-2354-1307
Joris Klundert https://orcid.org/0000-0003-4151-5089

ENDNOTES

[1] DBCs and DOTs are diagnosis-treatment combinations. DBCs were the predecessors of the DOTs. Prior to 2012, there were more than 29,000 different DBCs (Roos et al., 2020). With the introduction of the DOTs, the number of diagnosis-treatment combinations was reduced substantially to approximately 4400.

[2] A representative patient in our sample is male, 77 years of age, with the long-term condition coronary heart disease, and belonging to SES category 5.

REFERENCES

Agency for Healthcare Research and Quality. (2006). *Inpatient quality indicators*. https://www.qualityindicators.ahrq.gov/Downloads/Modules/iqi/v30/2006-Feb-InpatientQualityIndicators.pdf

Blom, M. T., Beesems, S. G., Homma, P. C., Zijlstra, J. A., Hulleman, M., van Hoeijen, D. A., Tijssen, J. G. P., Tan, H. L., & Koster, R. W. (2014). Improved survival after out-of-hospital cardiac arrest and use of automated external defibrillators. *Circulation*, *130*(21), 1868–1875.

Chapko, M. K., Liu, C. F., Perkins, M., Li, Y. F., Fortney, J. C., & Maciejewski, M. L. (2009). Equivalence of two healthcare costing methods: Bottom-up and top-down. *Health Economics*, *18*(10), 1188–1201.

Chen, L. M., Jha, A. K., Guterman, S., Ridgway, A. B., Orav, E. J., & Epstein, A. M. (2010). Hospital cost of care, quality of care, and readmission rates: Penny wise and pound foolish? *Archives of Internal Medicine*, *170*(4), 340–346.

Chin, C. T., Chen, A. Y., Wang, T. Y., Alexander, K. P., Mathews, R., Rumsfeld, J. S, Roe, M. T., Fonarow, G. C., Peterson, E. D., & Roe, M. T. (2011). Risk adjustment for in-hospital mortality of contemporary patients with acute myocardial infarction: The Acute Coronary Treatment and Intervention Outcomes Network (ACTION) Registry®–Get With The Guidelines (GWTG)™ acute myocardial infarction mortality model and risk score. *American Heart Journal*, *161*(1), 113–122.

Douven, R., Burger, M., & Schut, F. (2020). Does managed competition constrain hospitals' contract prices? Evidence from the Netherlands. *Health Economics, Policy and Law*, *15*(3), 341–354.

Drummond, M. F., Sculpher, M. J., Claxton, K., Stoddart, G. L., & Torrance, G. W. (2015). *Methods for the economic evaluation of health care programmes*. Oxford University Press.

Dutch Hospital Association. (2018). *Brancherapport algemene ziekenhuizen 2018*. https://ziekenhuiszorgincijfers.nl/assets/uploads/NVZ-Brancherapport-2018.pdf (In Dutch)

Hakkaart-van Roijen, L., Van der Linden, N., Bouwmans, C., Kanters, T., & Tan, S. S. (2015). *Kostenhandleiding: Methodologie van kostenonderzoek en referentieprijzen voor economische evaluaties in de gezondheidszorg*. Zorginstituut Nederland. (In Dutch)

Häkkinen, U., Rosenqvist, G., Iversen, T., Rehnberg, C., & Seppälä, T. T., & EuroHOPE Study Group. (2015). Outcome, use of resources and their relationship in the treatment of AMI, stroke and hip fracture at European hospitals. *Health Economics*, *24*, 116–139.

Häkkinen, U., Rosenqvist, G., Peltola, M., Kapiainen, S., Rättö, H., Cots, F., Geissler, A., Or, Z., Serdén, L., Sund, R., & EuroDRG group. (2014). Quality, cost, and their trade-off in treating AMI and stroke patients in European hospitals. *Health Policy*, *117*(1), 15–27.

Halbersma, R. S., Mikkers, M. C., Motchenkova, E., & Seinen, I. (2011). Market structure and hospital–insurer bargaining in the Netherlands. *The European Journal of Health Economics*, *12*(6), 589–603.

Jacobs, J. C., & Barnett, P. G. (2017). Emergent challenges in determining costs for economic evaluations. *Pharmacoeconomics*, *35*(2), 129–139.

Kaplan, R. S., & Porter, M. E. (2011). How to solve the cost crisis in health care. *Harvard Business Review*, *89*(9), 46–52.

Krabbe-Alkemade, Y. J. F. M., Groot, T. L. C. M., & Lindeboom, M. (2017). Competition in the Dutch hospital sector: An analysis of health care volume and cost. *The European Journal of Health Economics*, *18*(2), 139–153.

Marrie, T. J., & Wu, L. (2005). Factors influencing in-hospital mortality in community-acquired pneumonia: A prospective study of patients not initially admitted to the ICU. *Chest*, *127*(4), 1260–1270.

Mercier, G., & Naro, G. (2014). Costing hospital surgery services: the method matters. *PloS One*, *9*(5), e97290.

Oostenbrink, J. B., & Rutten, F. F. H. (2006). Cost assessment and price setting of inpatient care in the Netherlands. The DBC case-mix system. *Health Care Management Science*, *9*(3), 287–294.

Performation. (2020). *Standaard kosten en opbrengsten model, Handleiding 2020, Versie 1.0*. (In Dutch)

Peterson, P. N., Rumsfeld, J. S., Liang, L., Albert, N. M., Hernandez, A. F., Peterson, E. D., & Masoudi, F. A. (2010). A validated risk score for in-hospital mortality in patients with heart failure from the American Heart Association get with the guidelines program. *Circulation: Cardiovascular Quality and Outcomes*, *3*(1), 25–32.

Ponikowski, P., Voors, A. A., Anker, S. D., Bueno, H., Cleland, J. G., Coats, A. J., González-Juanatey, J. R., Harjola, V.-P., Jankowska, E. A., Jessup, M., Linde, C., Nihoyannopoulos, P., Parissis, J. T., Pieske, B., Riley, J. P., Rosano, G. M. C., Ruilope, L. M., Ruschitzka, F., Rutten, F. H., & van der Meer, P. (2016). 2016 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: The Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC) Developed with the special contribution of the Heart Failure Association (HFA) of the ESC. *European Heart Journal*, *37*(27), 2129–2200.

Porter, M. E. (2010). What is value in health care. *New England Journal of Medicine*, *363*(26), 2477–2481.

Romley, J. A., Goldman, D. P., & Sood, N. (2015). US hospitals experienced substantial productivity growth during 2002–11. *Health Affairs*, *34*(3), 511–518.

Roos, A. F., O'Donnell, O., Schut, F. T., Van Doorslaer, E., Van Gestel, R., & Varkevisser, M. (2020). Does price deregulation in a competitive hospital market damage quality? *Journal of Health Economics*, 102–328.

Rozenbaum, M. H., Mangen, M. J. J., Huijts, S. M., van der Werf, T. S., & Postma, M. J. (2015). Incidence, direct costs and duration of hospitalization of patients hospitalized with community acquired pneumonia: A nationwide retrospective claims database analysis. *Vaccine*, *33*(28), 3193–3199.

Schut, F. T., & Van de Ven, W. P. (2011). Effects of purchaser competition in the Dutch health system: Is the glass half full or half empty? *Health Economics, Policy and Law*, *6*(1), 109–123.

Sharabiani, M. T., Aylin, P., & Bottle, A. (2012). Systematic review of comorbidity indices for administrative data. *Medical Care*, *50*, 1109–1118.

Soekhlal, R. R., Burgers, L. T., Redekop, W. K., & Tan, S. S. (2013). Treatment costs of acute myocardial infarction in the Netherlands. *Netherlands Heart Journal*, *21*(5), 230–235.

Song, H., & Veeraraghavan, S. (2018). Quality of care. In *Handbook of healthcare analytics: Theoretical Minimum for conducting 21st century Research on healthcare operations* (pp. 79–108).

Tan, S. S., Rutten, F. F. H., Van Ineveld, B. M., Redekop, W. K., & Hakkaart-van Roijen, L. (2009). Comparing methodologies for the cost estimation of hospital services. *The European Journal of Health Economics*, *10*(1), 39–45.

vanIneveld, M., van Oostrum, J., Vermeulen, R., Steenhoek, A., & van de Klundert, J. (2016). Productivity and quality of Dutch hospitals during system reform. *Health Care Management Science*, *19*(3), 279–290.

vanIneveld, M., van Wijngaarden, J., & Scholten, G. (2018). Choosing cooperation over competition; hospital strategies in response to selective contracting. *International Journal of Health Planning and Management*, *33*(4), 1082–1092.

Vissink, C. E., Huijts, S. M., de Wit, G. A., Bonten, M. J., & Mangen, M. J. J. (2016). Hospitalization costs for community-acquired pneumonia in Dutch elderly: An observational study. *BMC Infectious Diseases*, *16*(1), 466.

Wiig, S., Aase, K., von Plessen, C., Burnett, S., Nunes, F., Weggelaar, A. M., Anderson-Gare, B., Calltorp, J., & Fulop, N. (2014). Talking about quality: Exploring how 'quality' is conceptualized in European hospitals and healthcare systems. *BMC Health Services Research*, *14*(1), 478.

World Health Organization [WHO]. (2018). *Saving lives, spending less: A strategic response to noncommunicable diseases (No. WHO/NMH/NVI/18.8)*. WHO.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

How to cite this article: Sülz, S., Wagenaar, H., & van de Klundert, J. (2021). Have Dutch Hospitals Saved Lives and Reduced Costs? A longitudinal patient-level analysis over the years 2013–2017. *Health Economics*, *30*(10), 2399–2408. https://doi.org/10.1002/hec.4391