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SYSTEMATIC REVIEW

A Systematic Review of the Association Between Hospital Cost/price and the Quality of Care

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Abstract

Background Limited empirical evidence exists regarding the effect of price changes on hospital behavior and, ultimately, the quality of care. Additionally, an overview of the results of prior literature is lacking.

Objective This study aims to provide a synthesis of existing research concerning the relationship between hospital cost/price and the quality of care.

Methods Searches for literature related to the effect of hospital cost and price on the quality of care, including studies published between 1990 and March 2019, were carried out using four electronic databases. In total, 47 studies were identified, and the data were extracted and summarized in different tables to identify the patterns of the relationships between hospital costs/prices and the quality of care.

Results The study findings are highly heterogenous. The proportion of studies detecting a significant positive association between price/cost and the quality of care is higher when (a) price/reimbursement is used (instead of cost); (b) process measures are used (instead of outcome measures); (c) the focus is on acute myocardial infarction, congestive heart failure, and stroke patients (instead of patients with other clinical conditions or all patients); and (d) the methodological approach used to address confounding is more sophisticated.

Conclusion Our results suggest that there is no general relationship between cost/price and the quality of care. However, the relationship seems to depend on the condition and specific resource utilization. Policy makers should be prudent with the measures used to reduce hospital costs to avoid endangering the quality of care, especially in resource-sensitive settings.

1 Introduction

Providing high-quality healthcare services at a reasonable cost is among the main policy goals in many countries [1]. In recent decades, hospital reimbursement systems have undergone substantial revisions in many countries to reduce spending and increase the quality of care. Hence, hospital prices have been subject to changes. In general, hospital pricing mechanisms range from fee-for-service price lists to global budgets, and diagnosis-related group (DRG) payments have spread across numerous countries [2]. DRG systems in various countries often rely on hospitals' cost information and are subject to changes over time. Theoretical works predict that increasing DRG prices provides incentives for hospitals to attract more patients [3]. Several empirical studies analyzed the impact of a change in reimbursement or price on hospital efficiency and the number of patients treated. For instance, Dafny [4] analyzed how hospitals respond to changes in DRG prices in the US and found no volume changes with DRGs subjected to the largest price increase. Street et al. [5] reviewed the impact of the introduction of a DRG system in Australia, Denmark, Norway, and Sweden. Their findings suggest that DRGs increased hospital efficiency by reducing the length of hospital stays and increasing hospital case volumes. Januleviciute et al. [6] investigated the impact of DRG price changes in Norwegian hospitals. Their findings provide evidence that hospitals react to this incentive by showing that an increase in prices leads to an increase in the number of patients treated.

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Key Points for Decision Makers

There is no general relationship between cost/price and the quality of care.

The relationship between cost/price and the quality of care seems to depend on the condition and specific resource utilization.

Policy makers should be prudent with the measures used to reduce hospital costs to avoid endangering the quality of care, especially in resource-sensitive settings.

Changes in price might also affect the hospital quality in several ways. First, if hospitals increase their volume after a price increase, the increase in volume could lead to a higher quality due to institutional learning effects [7, 8]. Additionally, higher prices might enable hospitals to spend more money (i.e. increase resources) on service provision, which might also have positive effects on the quality of care. However, hospitals might also be unwilling or unable to adjust their volume or resource input and instead maximize profits such that a price change has no effect on the quality of care.

Limited empirical evidence exists regarding the effect of price/price changes on hospital quality of care. Drawing upon evidence suggesting that a link exists between cost and quality appears to be fruitful because DRG prices in most countries are based on hospital cost information such that costs and prices are closely related. Several studies have investigated the cost-quality relationship, revealing highly heterogeneous characteristics and findings. This link is among the more controversial topics in health policy [9], and several potential mechanisms can explain the relationship between cost and quality. As outlined above, increases in resources (i.e. cost) could lead to quality increases. For instance, some technologies may lead to the increased use of medical personnel, material supplies, or training. In particular, some technologies may improve the efficiency of care delivery by reducing the procedure time, length of stay, or number of hospitalizations, thereby increasing the capacity of hospitals to treat additional patients. Consequently, the overall cost may increase, but such technology is likely to result in improved health outcomes for a higher number of patients. Some other technologies can help extend survival (e.g. in patients with life-threatening or chronic conditions), which may result in higher spending due to extended years of health-care utilization. However, in parallel, a given technology also allows individuals to live additional years with a higher quality of life or an improved health state, which could provide potential cost savings [10]. However, if resources are not used efficiently and effectively, changes in cost might be unrelated to the quality of care. In some instances, quality improvements may even decrease costs. Therefore, some technologies may reduce staff or time requirements or shift care to less costly care settings (e.g. inpatient to outpatient) while simultaneously improving the quality of care. For instance, percutaneous transluminal coronary angioplasty (PTCA) may facilitate a reduction in spending. The PTCA outcome improved following the introduction of coronary stents, leading to the reduced occurrence of restenosis, heart attacks, emergency coronary artery bypass grafting (CABG), and mortality [10]. In contrast, poor quality leads to more frequent readmissions and increased treatment of (avoidable) complications and hence, higher costs. Finally, the relationship between cost and quality might not be linear and unidirectional and might depend on the level of quality and cost. For instance, a *U*-shaped relation could exist in which increases in low levels of quality are associated with decreases in cost (if poor quality drives costs) until a certain threshold is reached; after reaching the threshold, further quality increases require increases in resources and, hence, higher cost. Simultaneously, one could imagine the opposite scenario in the form of an inverted *U*-shaped relationship in which quality increases initially require more resources and result in higher costs, and after a certain threshold is reached, synergy effects lead to increases in quality and simultaneous decreases in cost.

In summary, both price and cost can relate in various ways to hospital quality of care. In addition, several critical design characteristics may alter the association between cost/price and the quality of care [9]. Therefore, it is essential to separate the results based on defined key characteristics. In this study, we assess whether the results systematically vary depending on (i) the cost/price measures used; (ii) the quality measures used; (iii) the country in which the study was conducted; (iv) the clinical condition(s) investigated; and (v) the methodological approach used, particularly the degree to which studies approximate the causal effect based on the method used to address confounding.

We conducted a systematic review to synthesize the evidence regarding the association between hospital cost/price and the quality of care and identified sources of heterogeneity across studies. To date, only one systematic review performed by Hussey et al. [9] has analyzed the association between cost and the quality of care; however, some questions remain unanswered. First, their review only focuses on the association between cost measures and the quality of care; these authors do not consider price/reimbursement. Therefore, an overview of the price-quality relationship is lacking. Second, these authors exclude studies involving non-US data sources. Therefore, an overview of

cross-country comparisons is lacking. Finally, an overview of whether the results differ depending on the clinical condition is lacking. This paper addresses these gaps in the literature and considers studies published since 2012, substantially increasing the quantity of evidence.

Accordingly, this study aims to provide an overview of the existing evidence regarding how price affects the quality of care in the hospital setting. Therefore, we conduct a literature review of studies analyzing the association between price and the quality of care in hospitals. However, because few studies investigating this relationship exist and prices often rely on the costs of hospital care, we additionally provide a literature review of studies investigating the relationship between hospital cost and the quality of care.

2 Methods

This review is reported in accordance with The Preferred Reporting Items for Systematic Reviews and Meta-Analyses [11] guidelines. A review protocol was developed to identify all published articles investigating the association between hospital cost/price and the quality of care.

2.1 Search Strategy and Data Sources

We defined the search process for each relationship ('cost-quality' & 'price-quality') separately.

In the literature review of the cost-quality of care relationship, we first included all 29 studies identified by Hussey et al. [9] at the hospital level. Then, a three-step search process was used to identify new studies. First, by applying the problem, intervention, comparison, and outcome framework [12], we derived the primary keywords. Then, a limited preliminary search was performed using ScienceDirect, Scopus, and PubMed to analyze the primary keywords in the titles, abstracts, and keywords. Following this analysis, the final keywords were selected (the search was restricted to the titles and abstracts), and the search strategy was developed. The search strategy was tailored to individual databases based on their criteria but always followed the PICO framework (see Appendix A for the full electronic search strategy used to search PubMed as an example).

A systematic search was performed by following the search strategy using 4 electronic bibliographic databases, namely, PubMed (MedLine), Scopus, EconLit (ProQuest), and ScienceDirect, from 2012 to 2018,[1] and the search was repeated to identify studies published between 1990 and 2012 (the time horizon of Hussey et al. [9]), while the results were restricted to studies outside the USA.

Additionally, the references cited in the relevant studies were manually searched to identify additional relevant studies.

The retrieved articles were stored in EndNote (version X8). First, duplicate studies were excluded. Second, the title and abstract of each study were reviewed by two independent reviewers (SJ and VW) to exclude irrelevant articles. In cases where it was difficult to determine the relevance of an article based on the abstract, the full text was retrieved and examined by two reviewers (SJ and VW) independently to determine whether to include the paper. Then, the full texts of the relevant articles were examined by two reviewers (SJ and VW) separately using the selection criteria. All disagreements were resolved by either discussion or the involvement of a third researcher (JS).

For the literature review of the price-quality of care relationship, we conducted ad hoc searches and consultations with experts to derive an initial list of relevant studies, yielding four initial relevant studies [4, 13–15]. While attempting to derive keywords from these studies for a more systematic review, it became evident that the studies' wordings were highly heterogeneous such that no common keywords could be identified. Searching by terms, such as 'price', 'quality of care', and 'hospitals', yielded overflowing lists with less than 1% of the results being relevant to our context. Therefore, we decided to rely on backward and forward searching of the initial studies while assuming that we could identify the most relevant and influential studies concerning the "price-quality" association.

2.2 Selection Criteria

The studies were included if they were published, analyzed the association between cost/price and the quality of care in the hospital setting, employed quantitative methodology and were available (full text) in English.

We restricted the quality of care measurement to outcome and process measures as valid and reliable indicators of what actually occurs in medical practice [16]. Moreover, we restricted the cost/price measures to monetary measures. Eight studies included by Hussey et al. [9] were excluded because they relied on a care intensity index, which is a nonmonetary measure (4 studies), composite quality measure (i.e. composite measure of 30-day mortality and kidney transplant volume), which was not based on outcome or process measures (1 study), patient experience (1 study), caregiver rating of the patients' quality of death (1 study), and a structure measure (1 study).

No restrictions were imposed on the study design or duration. Articles were excluded if they were reviews or nonprimary articles (newspaper articles, editorials, book chapters, and conference abstracts).

[1] The authors continued to add new results up to March 2019.

2.3 Data Extraction

To ensure that all data relevant to the question of interest of the review were collected, the data were entered into two tables. Table 1 provides information regarding the characteristics of each study, e.g. the population and data years. Another table (see Appendix C) provides information regarding each finding, i.e. association. As one study can have more than one finding, this table is more detailed and includes information regarding the type of cost/price measure, type of quality measure, and clinical condition investigated per association tested. All disagreements were resolved by either discussion or the involvement of a third researcher (JS).

The extracted data included the articles' title, author, year of the study, the country in which the study was conducted, samples and years of data collection, study design, clinical condition(s) investigated, types of quality measures, types of cost/price measures, methodological approach, and the direction of the association/causality between hospital cost/price and the quality of care. As some studies reported more than one result (i.e. different countries, conditions, and quality and/or cost measures), the number of data entries ("results," "associations") exceeds the number of studies.

2.4 Data Analysis

The extracted data were analyzed using a narrative format. As the studies were highly heterogeneous, a meta-analysis was not performed.

The main study outcome of interest was the direction and statistical significance of the reported association between the hospital cost/price and the quality of care. We evaluated the direction of the association by indicating whether the association was (significantly linear/nonlinear) positive, (significantly linear) negative, (significantly) U-shaped/inverted U-shaped, or not significant.

Statistically significant ($p < 0.1$) results were classified according to the direction of the association. Some empirical studies revealed a simple, linear cost-quality relationship and assumed a constant marginal cost associated with quality improvement. A linear positive (negative) association implies that the higher the hospital cost/price, the higher (lower) the quality of care. If different ordered categories were compared with a reference group, when either at least 75% of the coefficients reported were significantly linear positive/negative or all coefficients were in the same direction with at least one being significant, the direction of the association was classified as positive/negative.

Additionally, some other studies assumed that the marginal cost may vary over the range of quality. These studies allowed for a nonlinear association between costs and quality by including the squared terms in their estimation model. If the squared term was significant, the associations were coded as nonlinear. Such significant nonlinear associations were further categorized into the following three possible forms: (i) U-shaped relationship (i.e. in the lower range of quality, quality improves as costs decrease; however, after a certain threshold, higher quality can only be achieved with higher costs); (ii) inverted-U relationship (i.e. in the lower range of quality, quality improves with increasing costs; however, after a threshold, significant quality improvement can be achieved with relatively small increments in cost (decreasing marginal cost); and (iii) nonlinear positive relationship (i.e. quality improvement is achieved with increasing costs but decreasing marginal returns) (see Figs. 1 and 2). These forms were identified based on the authors' reports. In the results section, we merged the significant linear positive and nonlinear positive relationships due to their positive direction. Studies that did not find/report a significant result ($p > 0.1$) were coded as not significant.

The quality of care measures were classified into the following two categories: outcome (e.g. mortality, readmission, complication/morbidity, quality of life indexes, and composite measures) and process measurements. Process indicators vary depending on the clinical conditions investigated; therefore, we classified the process indicators based on the clinical condition [i.e. process measures for CABG, pneumonia, congestive heart failure (CHF), acute myocardial infarction (AMI), and stroke]. For instance, two process measures for CABG are prophylactic antibiotic administered on the day of the intervention and antibiotic discontinued within 48 h.

The cost measures were classified into the following two categories: (i) accounting costs reflecting the best use of hospital resources (measured by the providers' accounting system or cost-to-charge ratio) and (ii) costs due to inefficiency, i.e. costs associated with waste or inefficiency, obtained from a cost frontier analysis or data envelopment analysis. As very few studies assessed cost due to inefficiency, we do not differentiate the two categories in the results section.

The price measures were based on price/reimbursement, which reflects the payment that hospitals or other healthcare providers receive for providing medical services to patients (this could be a DRG-based payment or other reimbursement and price changes).

The clinical conditions were classified into the following 6 main categories: (i) AMI, (ii) CHF, (iii) pneumonia, (iv) stroke, (v) CABG, and (vi) hip replacement/fracture. We further aggregated various surgical procedures that had fewer than 5 associations into one category named other surgical procedures, which included vascular surgery, colectomy, abdominal aortic aneurysm repair, cholecystectomy, general surgery, orthopedic surgery, cardiothoracic or gastrointestinal operation, knee replacement surgery, varicose vein surgery, and groin hernia surgery. Moreover, we aggregated

Table 1 Characteristics of included studies (on the study level)

Study (ref.) (year), country	Sample characteristics and size	Data years
Auerbach et al. [25] (2010), USA	81,289 patients aged ≥ 18 cared for by 1451 physicians at 164 hospitals admitted for CABG	2003–2005
Birkmeyer et al. [26] (2012), USA	Patients (aged ≥ 65 & < 99) undergoing the following 4 procedures: CABG (1060 hospitals, 221,894 patients), hip replacement (1839 hospitals, 219,777 patients), abdominal aortic aneurysm repair (728 hospitals, 57,522 patients), colectomy procedures (1227 hospitals, 73,772 patients)	2005–2007
Bradbury et al. [27] (1997), USA	11,043 cholecystectomies performed by 218 surgeons in 43 Pennsylvanian hospitals	1990–1991
Bradbury et al. [28] (1994), USA	Total of 51,394 adults' admissions aged > 17 with one of the 10 most frequently occurring DRGs, in 43 Pennsylvania hospitals	1989–1990
Broderick et al. [29] (2015), USA	148,348 adult patients aged ≥ 18 with diverticulitis who underwent partial colectomy	1998–2010
Carey & Burgess [30] (1999), USA	The group of 137 non-psychiatric VA hospitals	1988–1993
Chan et al. (2015) [31], USA	All pediatric admissions aged < 18 from Kids' Inpatient Database undergoing congenital heart surgery from 38 states in 2006 and 44 states in 2009	2006–2009
Chen et al. [32] (2010), USA	Adults aged > 65 with a primary diagnosis of CHF (in 3146 hospitals, 518,473 discharges, and 400,068 unique patient) or pneumonia (in 3152 hospitals, 443,564 discharges, and 399,841 unique patient)	2006
Cohen et al. [33] (2015), Canada	Cohort of 30,939 first-time AMI patients aged < 40 < 105 admitted to Ontario hospitals with a most responsible diagnosis of AMI (ICD-10 code [I21])	2007–2010
Cutler [12] (1995), USA	Almost 30,000 Medicare recipients, with over 40,000 hospital admissions for the elderly aged ≥ 65 in the six New England states	1981–1988
Dafny [4] (2005), USA	All admissions to DRG pairs in hospitals financed under PPS	1986–1991
Deily and McKay [34] (2006), USA	417 acute care Florida hospitals	1999–2001
Doyle [35] (2015), USA	First strategy: "non-deferrable" emergent 351,701 Medicare beneficiaries hospitalized through ED second strategy: the universe of elderly hospital inpatient admissions in New York within 5 miles of an ambulance referral boundary	(1) 2002–2008 Medicare patients (2) secondary analysis NYC (2000–2006)
Duggan [13] (2000), USA	Newborns in 397 general acute care Californian hospitals	1990–1995
Fleming [8] (1991), USA	Medicare beneficiaries discharged in 656 hospitals	1985
Gani et al. [36] (2016), USA	239,195 patients aged > 18 in 3498 hospitals undergoing an elective cardiothoracic or gastrointestinal procedure from NIS Database	2012
Glance et al. [37] (2010), USA	67,124 trauma patients admitted to 73 trauma centers from Nationwide Inpatient Sample, with a principal diagnosis of trauma (ICD-9-CM: 800 & 9599) to a Level I or II trauma centers with American hospitals	2006
Gupta et al. [38] (2017), USA	917,663 patients at 47 hospitals from 1 day through 18 years old admitted to a PICU during their hospital stay	2004–2015
Gutacker et al. [39] (2013), UK	Data from the PROMs program cover from April 2009 to March 2010 and are published at hospital–level by the NHS Information Centre for all providers of NHS-funded care	2009–2010
Haas et al. [40] (2013), Germany	101 psychosomatic patients with somatoform pain disorder at Charite Universitaetsmedizin, Berlin	2006–2010

Table 1 (continued)

Study (ref.) (year), country	Sample characteristics and size	Data years
Hadley et al. [41] (2011), USA	17,438 elderly aged > 64, who entered the Medicare Current Beneficiary Survey	1991–1999
Häkkinen et al. [42] (2014), [Finland, France, Germany, Spain, Sweden]	Patient-level data from 5 European countries in the treatment of the AMI (100* hospitals) and stroke (93* hospitals) *(number of hospitals and cases varied by country)	2008–2009
Häkkinen et al. [1] (2015), [Finland, Hungary, Italy, Norway, and Sweden]	Around 250 European hospitals in 5 countries used patient-level data [for Italy, we had data from only one region (Lazio, population 55 million), and one town (Turin, population 09 million); Stroke data for Norway were not available]	Finland (2007–8), Hungary (2007–8), Italy (2007–8), Sweden (2007–8), Norway (2009)
Hvenegaard et al. [43] (2010), Denmark	3754 patients admitted for vascular surgery in six vascular departments	2004
Jha et al. [44] (2009), USA	Medicare patients discharged from 4048 acute care hospitals with index AMI (2,236), CHF (2807) or pneumonia (2857)	2004
Kaestner and Silber [45] (2010), USA	8,529,595 Medicare patients from 3321 hospitals who were admitted to hospitals for surgery (general, orthopedic and vascular), and medical conditions (AMI, CHF, stroke, and GI bleeding)	2001–2005
Kang et al. [46] (2017), Korea	69 hospitals that treated 6599 AMI episodes: (40 general tertiary hospitals accounted for 4957 AMI episodes, and 29 general hospitals accounted for 1642 AMI episodes)	2008
Kittelsen et al. [47] (2015), major Nordic countries (Norway, Sweden, Finland, and Denmark)	160 acute somatic hospitals with a 24-h emergency department or at least 2 medical or surgical specialties in 4 major Nordic countries	2008–2009
Kruse&Christenden [48] (2013), Denmark	20,325 admission for vascular surgery at 9 vascular surgery department (depending on the patient-level and department-level)	2005–2009
Lagu et al. [49] (2011), USA	166,931patients aged ≥ 18 with sepsis at 309 hospitals	2004–2006
lee et al. [50] (2013), Japan	3958 patients admitted with stroke to hospitals in Kyoto Prefecture	2009–2010
Mckay and Deily [51] (2008), USA	A national sample of 3384 short-term, acute-care hospitals [with at least 16 beds and 100 discharges] in the USA in 1999, and 3343 observations in 2000, and 3183 observations in 2001, for a total of 9910 across the three years	1999–2001
Morey et al. [52] (1992), USA	301 US hospitals	1983
Mukammel et al. [53] (2001), USA	Medicare fee-for-service patients in all nonfederal, acute-care, short-term hospitals (1927 hospitals in 134 metropolitan statistical areas, with five or more acute-care hospitals) dead because of all causes and acute myocardial infarction, congestive heart failure, pneumonia, stroke, cardiac artery bypass graft procedures, and hip-replacement surgery	1990
Mukammel et al. [54] (2002), USA	338 acute-care hospitals in California	1982–1989
Ong et al. [55] (2009), USA	3999 elderly aged ≥ 65 Medicare beneficiaries hospitalized with a principal diagnosis of heart failure at six California teaching hospitals [depends on looking forward and looking back cohort]	2001–2005
Osnabrugge et al. [56] (2014), USA	42,839 patients across 17 centers performing CABG	2003–2013
Pasquali et al. [57] (2015), USA	30,670 children aged < 18 undergoing congenital heart surgery in 27 hospitals	2006–2010
Picone et al. [58] (2003), USA	5332 elderly Medicare beneficiaries' aged ≥ 65 admitted to hospitals with primary diagnoses of hip fracture, stroke, coronary heart disease, or congestive heart failure for stays of 30 days or less	1984–1995
Ramley et al. [59] (2011), USA	2,545,352 patients admitted with one of the following conditions: AMI, CHF, acute stroke, gastrointestinal hemorrhage, hip fracture, pneumonia at 208 Californian hospitals in The Dartmouth Atlas of Health Care	1999–2008

Table 1 (continued)

Study (ref.) (year), country	Sample characteristics and size	Data years
Romely et al. [60] (2013), USA	Nationwide Inpatient Sample of 2,635,510 patients admitted to 1201 US acute-care hospitals for 6 major medical conditions	2003–2007
Romely et al. [61] (2014), USA	35,446 children aged < 18 undergoing surgery for CHF admitted to 332 US acute-care hospitals	2003, 2006, and 2009
Saleh et al. [62] (2012), USA	48,574 pneumonia patients aged > 18 admitted to 189 New York hospitals	2005
Sasaki et al. [63] (2017), Japan	20,926 patients from 261 acute-care hospitals enrolled in the QIP	2010–2011
Schreyögg & Stargardt [64] (2010), USA	116 VHA hospitals with 35,279 patients with hospitalization for AMI	2000–2006
Stargardt et al. [14] (2014), Germany	Patients with an admission for AMI, insured in TK in 318 German hospitals	2004–2006
Yeh et al. [65] (2014), USA	A 20% stratified sample of HCUP-NIS discharges with a primary diagnosis of acute pancreatitis from community US hospitals	2010

AMI acute myocardial infarction, *CABG* coronary artery bypass grafting, *CHF* congestive heart failure, *DRG* diagnosis-related group, *ED* emergency department, *GI* gastrointestinal, *HCUP-NIS* Healthcare Cost and Utilization Project-Nationwide Inpatient Sample, *QIP* quality improvement plan, *TK* Techniker Krankenkasse, *VHA* Veterans Health Administration

all diverse medical conditions with fewer than 5 associations into one category named other medical conditions, which included circulatory system diseases, cerebrovascular disorder, bronchitis and asthma, cardiac arrhythmia, angina pectoris, gastrointestinal hemorrhage, esophagitis, nutritional disorders, sepsis, emergency medical conditions, pediatric critical care, psychosomatic patients with somatoform pain disorder, and acute pancreatitis. Studies that either considered no specific conditions or all patients overall were categorized as indeterminate.

The countries were classified into twelve categories, including the USA, Canada, the UK, Germany, Italy, Spain, France, Hungary, Japan, Korea, Nordic countries (i.e. Sweden, Norway, Finland, and Denmark), and associations based on pooled sample countries.

The systematic search included the years between 1990 and 2018. We distinguished among the following three periods of approximately 10 years each: (i) 1990–1999, (ii) 2000–2009, and (iii) 2010–2018.

We classified the studies' methods by the degree to which they approximated the causal effect based on the method used to address confounding as follows: (i) experimental studies, including RCT and natural or quasi-experiments (e.g. difference-in-difference design); none of our reviewed studies used an experimental design; (ii) nonexperimental studies using techniques that control for unobservables, such as an instrumental variable approach; (iii) studies controlling for observables to adjust for confounding via a regression approach (e.g. panel or cross-section); and (iv) studies using a correlation analysis.

3 Results

In total, 4416 articles were retrieved from the systematic search for studies newer than 2012 and studies conducted outside the USA between 1990 and 2012. After removing duplicates, 2225 articles remained. Following the exclusion of articles based on the titles or abstracts, 54 articles were subjected to full-text reading. The full texts of the included studies were independently examined by two reviewers. On the basis of the inclusion and exclusion criteria, 22 articles were included through the systematic search (see Fig. 3). In addition, 21 studies included by Hussey et al. and four initial studies investigating the 'price-quality' relationship were added to our final review (i.e. a total of 47 studies). No additional articles were identified by searching the reference lists of these four studies. Moreover, all studies identified through the forward search had already been detected by the systematic search processes targeting the cost-quality relationship.

In total, 47 studies were included in the review, including nine studies that analyzed the price-quality relationship

and 38 studies that assessed the cost-quality relationship. In these 47 studies, 225 associations between cost/price and quality measures were reported. The data extracted from the included studies are presented in Table 1, Appendix B (study level), and Appendix C (association level).

Most studies (66%) were conducted in the USA, 29% of the studies were conducted in Europe, and the remaining 5% of the studies were conducted in Asia. Additionally, most studies (69%) were published between 2010 and 2018.

The evidence regarding the association between cost/price and the quality of care is summarized in Appendix C. The included studies were widely heterogeneous in terms of the cost measures, quality measures, clinical conditions, countries, and methods used to control for observables and unobservables.

Overall, 74 (33%) associations between the unit cost/price and the unit quality were significantly positive, 33 (15%) associations were significantly negative, 11 (5%) associations were significantly U-shaped/inverted-U-shaped, and 105 (47%) associations were not significant.

3.1 Findings by Cost/price Measurement

Among the included studies, cost/price was assessed via multiple indicators (Table 2). Of the 225 associations, 165 (73%) were based on cost measures (accounting costs or costs due to inefficiency), while 60 (27%) associations relied on price/reimbursement measures. Compared to the studies using cost measures, a larger share of the significant positive associations occurred in the studies based on price measures (33% vs 37%, respectively). Overall, the results of the associations were more mixed among the cost measure associations.

3.2 Findings by the Quality of Care Measurement

As presented in Table 2, the quality of care was assessed using different outcome and process indicators. The outcome indicators comprised the following five main categories: mortality, readmission, complication/morbidity, composite measures, and quality of life indexes. These five categories consist of several subcategories or different measures. Mortality comprises in-hospital, infant and posthospital mortality (i.e. 30-day, 6-month, 1-, 2- and 3-year mortality, and time to death with a maximum of 365 days). Readmission covers return periods of 14 days, 30 days, and one year. The quality-of-life indexes include generic PROM (such as the EQ-5D and EQ-VAS), condition-specific PROM (including the Oxford Hip Score, Oxford Knee Score, and Aberdeen Varicose Vein Questionnaire), the Health Activity Limitations index, and the overall functioning of mental health (MCS-8 score).

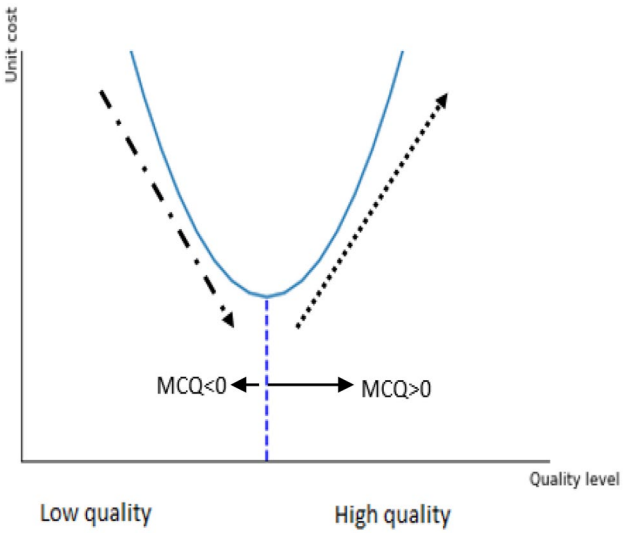

Fig. 1 U-shaped cost-quality relationship. *MCQ* marginal cost of quality

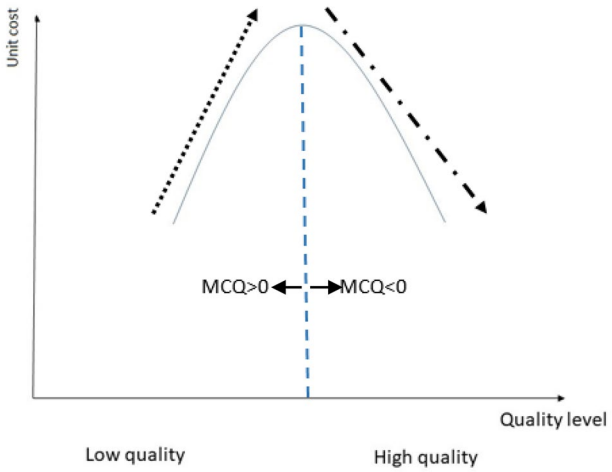

Fig. 2 Inverted u-shaped cost-quality relationship. *MCQ* marginal cost of quality

In total, 192 (85%) associations relied on the outcome quality of care measures, while only 33 (15%) associations were based on process measures. The most commonly used outcome measure was mortality (140 of 192, 73%). Among the 140 studies using mortality, most relied on the 30-day mortality (63 of 140, 45%) or in-hospital mortality (57 of 140, 41%).

The share of nonsignificant associations reported when process measures were used was lower than that when outcome measures were used (36–48%). The shares of both significant positive and significant negative associations using process measures were higher than those using outcome measures. When further differentiating among the types of

outcome measures, the share of significant negative associations was especially high using complications/comorbidities as the quality measure. This result is intuitive because as a negative quality outcome, complications have the highest potential to increase costs (i.e. the lower the quality and the greater the number of complications, the higher the costs).

3.3 Findings by Clinical Condition(s)

Of the reviewed studies, 89% focused on specific conditions, and the other 11% of the studies considered either no specific conditions or all patients. Of those that focused on specific condition(s), the most commonly studied conditions were surgical procedures (32 of 201, 16%), AMI (30 of 201, 15%), stroke (28 of 201, 14%), pneumonia (20 of 201, 10%), and CHF (19 of 201, 9%). The most positive evidence of an association between cost/price and the quality of care was observed in AMI, CHF, and stroke. Among the 30 studies investigating AMI, 21 (70%) found a significantly positive association; of the 19 studies investigating CHF, 12 (63%) found a significantly positive association; and of the 28 studies investigating stroke, 14 (50%) found a significantly positive association. Relatively higher shares of significantly negative associations were found in the other surgical procedures (12 of 32 associations, 38%), CABG (4 of 11, 36%), and pneumonia (6 of 20, 30%). The share of nonsignificant associations was especially high in the other medical conditions (32 of 49, 65%) and pneumonia (13 of 20, 65%).

3.4 Findings by Country

In total, 148 of 225 or 66% of all associations were based on US data. The second most frequent data source was Nordic countries (Denmark, Sweden, Finland, and Norway), with an aggregate of 32 associations. Only two other countries—Japan and the UK—yielded at least 10 associations. Among the countries with at least 10 associations, the findings of two data origins deviate substantially from the overall distribution of findings as follows: the Japanese data had a high share of significantly positive findings (6 of 10, 60%), and the UK data had a high share of U-shaped associations (27%).

3.5 Findings by Year

Most studies were conducted during the last period (from 2010 to 2018, representing 69% of all associations), and the share of nonsignificant associations decreased over time (from 68% in 1990–1999 to 40% in 2010–2018). The most mixed results were reported during the period from 2000 to 2009.

3.6 Findings by Methodological Approach

The included studies exhibited considerable heterogeneity in methodology. Of the 225 associations, 8 (4%) studies used a correlation analysis, 163 (72%) studies controlled for observables via a regression analysis (e.g. panel or cross-section), and 54 (24%) studies controlled for unobservables using instrumental variables to address confounding.

As the degree of sophistication and approximation of the true causal effect increased, the share of nonsignificant associations decreased (from 75% in the studies using correlation analyses to 32% in the studies using IV analyses). Of all methods, the IV approach yielded the highest share of positive associations (50% compared to 29% or less in the studies using other methods).

3.7 Findings by Price Measurement Sub-section

In the final step, we focused on the findings of studies using price, as these studies have not been previously subjected to a literature review. In particular, we aim to assess whether a distinct picture emerges regarding findings solely based on the price-quality relationship. The 60 associations included are divided by the previously used categorizations and summarized in Table 3. In total, as already displayed in Table 2, the associations are slightly more often significantly positive, and no study found a U-shaped relationship between price and the quality of care.

Regarding the quality-of-care measurement, 53 (88%) associations relied on an outcome quality measure, while only 7 (12%) associations were based on process measures. The most commonly used outcome measure was mortality (40 of 53, 75%). Process measures were investigated only in the case of stroke, and when process measures were used, the share of nonsignificant associations was lower than that when outcome measures were used (14–39%). Of the reviewed studies investigating the price-quality association, the most commonly studied conditions were medical conditions (24 of 56, 43%). The most positive evidence was observed in stroke, AMI, and CHF. In total, 83% of all associations were based on US data, and the Japanese data had a high share of significantly positive findings (6 of 9, 60%). Most studies were conducted during the last period (from 2010 to 2018, representing 50% of all associations), and the share of nonsignificant associations decreased over time (from 85% in 1990–1999 to 17% in 2010–2018). Of all methods, the IV approach yielded the highest share of positive associations (87.5% compared to 67% or less in studies using other methods).

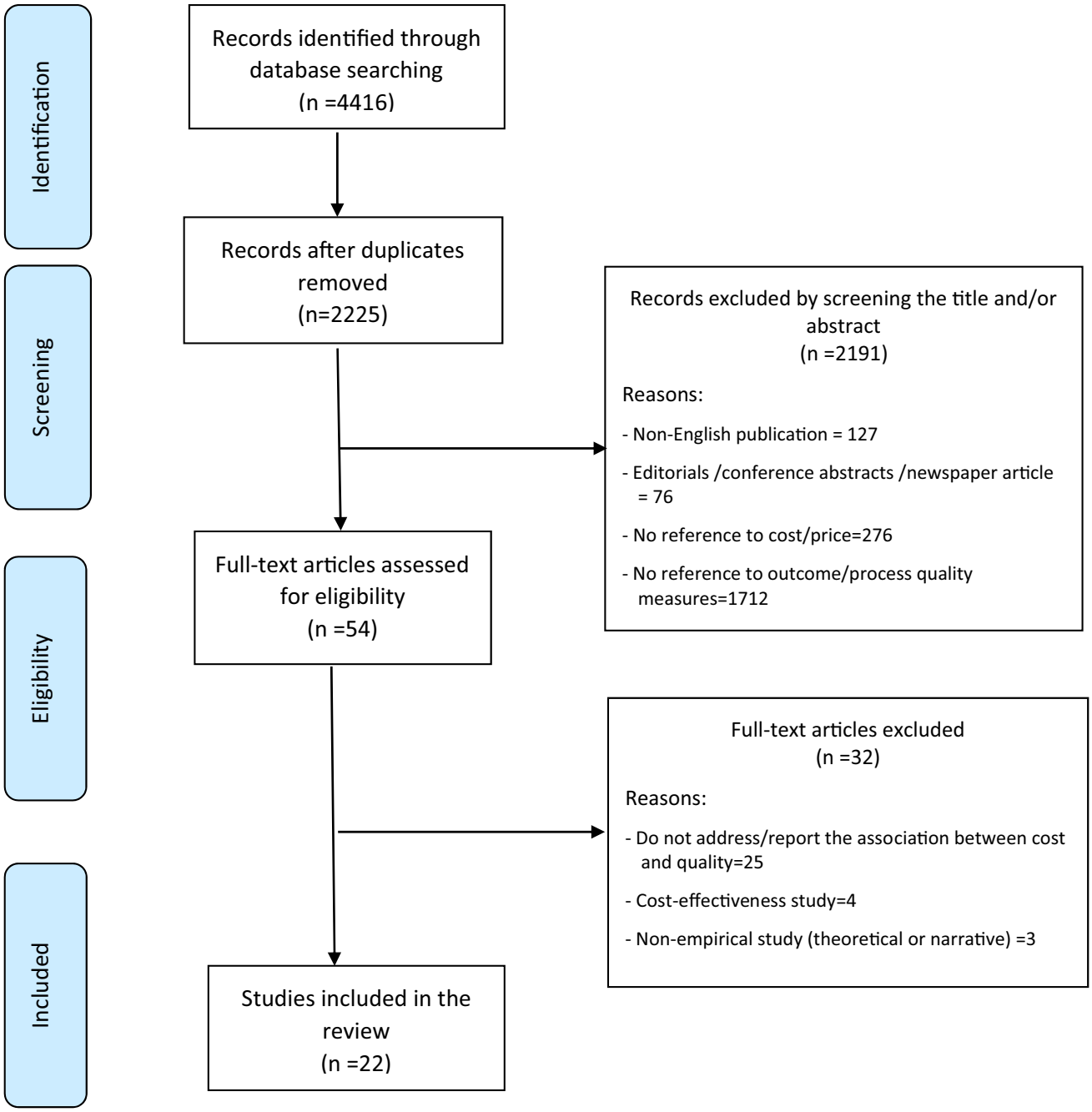

Fig. 3 Flow diagram of the literature search

4 Discussion

In this study, we conducted a systematic literature review to identify and summarize evidence regarding the association between cost/price and the quality of care in the hospital setting. To the best of our knowledge, this study represents the first comprehensive systematic literature review focusing on the association between cost/price and the quality of care that is not geographically restricted. The most frequent finding in our included studies was a nonsignificant association between price/cost and the quality of care (47% of all associations). We conducted a systematic review to synthesize the evidence regarding the association between hospital cost/price and the quality of care and identify sources of heterogeneity across studies. To date, only one systematic review performed by Hussey et al. [9] analyzed the association between cost and the quality of care and aggregated and reported the results at the study level [9]. Our findings

Table 2 Overview on study findings on the cost/price-quality relationship in total and for different subcategories

	Sign linear/non-linear positive	Sign linear negative	Sign non-linear U-shaped/ inverted U-shaped	Not sign	Total
	(*n*) (% of ni)	(*n*) (% of ni)	(*n*) (% of ni)	(*n*) (% of ni)	(n_i) (% of 225)
Total	**76 (33%)**	**33 (15%)**	**11 (5%)**	**105 (47%)**	**225 (100%)**
Cost/price measure					
Price/reimbursement	22 (37%)	7 (11%)	0 (0%)	31 (52%)	**60 (27%)**
Cost (aggregate)	54 (33%)	26 (16%)	11 (6%)	74 (45%)	**165 (73%)**
Quality of care measure					
Outcome	**62 (32%)**	**26 (14%)**	**11 (6%)**	**93 (48%)**	**192 (85%)**
Mortality	56 (40%)	12 (9%)	4 (3%)	68 (49%)	**140 (62%)**
Readmission	3 (25%)	1 (8%)	3 (25%)	5 (42%)	**12 (5%)**
Complication/morbidity	0 (0%)	12 (46%)	1 (4%)	13 (50%)	**26 (12%)**
Quality of Life Index (QoL)	3 (23%)	1 (8%)	3 (23%)	6 (46%)	**13 (6%)**
Composite measure	0 (0%)	0 (0%)	0 (0%)	1 (100%)	**1 (05%)**
Process measures	**14 (43%)**	**7 (21%)**	**0 (0%)**	**12 (36%)**	**33 (15%)**
Process (unspecified)	1 (100%)	0 (0%)	0 (0%)	0 (0%)	**1 (05%)**
CABG process measure	2 (29%)	3 (43%)	0 (0%)	2 (29%)	**7 (3%)**
Pneumonia process measure	0 (0%)	4 (33%)	0 (0%)	8 (67%)	**12 (5%)**
CHF process measure	4 (80%)	0 (0%)	0 (0%)	1 (20%)	**5 (2%)**
AMI process measure	1 (100%)	0 (0%)	0 (0%)	0 (0%)	**1 (05%)**
Stroke process measure	6 (86%)	0 (0%)	0 (0%)	1 (14%)	**7 (3%)**
Clinical conditions					
AMI	21 (70%)	0 (0%)	0 (0%)	9 (30%)	**30 (135%)**
CHF	12 (63%)	4 (21%)	0 (0%)	3 (16%)	**19 (8%)**
Pneumonia	1 (5%)	6 (30%)	0 (0%)	13 (65%)	**20 (9%)**
Stroke	14 (50%)	0 (0%)	2 (7%)	12 (43%)	**28 (125%)**
CABG	2 (18%)	4 (36%)	0 (0%)	5 (45%)	**11 (5%)**
Hip fracture/replacement	1 (8%)	1 (8%)	4 (33%)	6 (50%)	**12 (5%)**
Other surgical procedures	5 (16%)	12 (38%)	3 (9%)	12 (38%)	**32 (14%)**
Other medical conditions	11 (22%)	4 (8%)	2 (4%)	32 (65%)	**49 (22%)**
Not available conditions	9 (38%)	2 (8%)	0 (0%)	13 (54%)	**24 (11%)**
Country					
Canada	2 (100%)	0 (0%)	0 (0%)	0 (0%)	**2 (1%)**
Germany	2 (50%)	0 (0%)	0 (0%)	2 (50%)	**4 (2%)**
Italy	3 (75%)	0 (0%)	0 (0%)	1 (25%)	**4 (2%)**
Nordic countries (Denmark, Estonia, Finland, Iceland, Norway, Sweden)	8 (25%)	4 (1%)	3 (9%)	17 (53%)	**32 (14%)**
Japan	6 (60%)	0 (0%)	0 (0%)	4 (40%)	**10 (4%)**
Korea	0 (0%)	0 (0%)	0 (0%)	1 (100%)	**1 (05%)**
France	0 (0%)	0 (0%)	0 (0%)	2 (100%)	**2 (1%)**
Hungary	2 (50%)	0 (0%)	1 (25%)	1 (25%)	**4 (2%)**
Spain	0 (0%)	0 (0%)	0 (0%)	2 (100%)	**2 (1%)**
UK	1 (9%)	1 (9%)	3 (27%)	6 (55%)	**11 (5%)**
USA	49 (33%)	28 (19%)	4 (3%)	67 (45%)	**148 (66%)**
Pooled Sample	3 (60%)	0 (0%)	0 (0%)	2 (40%)	**5 (25%)**
Year					
1990–1999	3 (8%)	5 (14%)	4 (11%)	25 (68%)	**37 (16%)**
2000–2009	14 (41%)	2 (6%)	0 (0%)	18 (53%)	**34 (15%)**
2010–2019	59 (38%)	26 (17%)	7 (5%)	62 (40%)	**154 (69%)**

Table 2 (continued)

	Sign linear/non-linear positive	Sign linear negative	Sign non-linear U-shaped/ inverted U-shaped	Not sign	Total
	(*n*) (% of ni)	(*n*) (% of ni)	(*n*) (% of ni)	(*n*) (% of ni)	(n_i) (% of 225)
Methods					
Correlation	2 (25%)	0 (0%)	0 (0%)	6 (75%)	**8 (4%)**
Cfo—regression approach	47 (29%)	29 (18%)	5 (3%)	82 (50%)	**163 (72%)**
CfU—IV approaches	27 (50%)	4 (7%)	6 (11%)	17 (32%)	**54 (24%)**

CfO controlling for observables, *CfU* controlling for unobservables, *IV* instrumental variable

are partially contradictory to those reported by Hussey et al. [9], who found nonsignificant or mixed findings in only 26% of their studies. Some differences can be explained by our inclusion of price instead of only costs, the inclusion of the clinical conditions investigated in each paper, the addition of countries other than the USA, and the longer time frame, all leading to increases in the share of nonsignificant findings. Moreover, a large part might also be due to differences in the classification of the results and the level of aggregation (study level vs association level).

In summary, we find highly mixed evidence of the association. One potential explanation is the multiple ways that price and cost can relate to the quality of care. Another explanation might be the high heterogeneity across the included studies. Most notably, the overall pattern of the relationships between hospitals' price-quality and cost-quality were quite similar. Indeed, some variations can be explained by the studies' characteristics. In particular, we find that the proportion of studies that detected a significantly positive association is higher when: (a) price/reimbursement is used (instead of cost); (b) process measures are used (instead of outcome measures); (c) the focus is on AMI, CHF, and stroke patients (instead of patients with other clinical conditions or all patients); and (d) the methodological approach used to address confounding is more sophisticated. In the following, we discuss the extent to which these results can be explained to increase our understanding of the cost/price-quality of care relationship.

Regarding our findings, the share of positive associations between cost/price and the quality of care is higher when price is assessed instead of cost. One potential mechanism implies that in the face of a price increase for a particular diagnosis or treatment, more patients may be admitted to the hospital (i.e. volume increases), which could lead to a higher quality of care due to institutional learning [8, 17, 18]. Moreover, higher prices might enable hospitals to spend more on service provision, which might have a positive effect on the quality of care. This line of argument is supported by prior evidence showing that when the price/cost margins are high, hospitals may compete in quality to attract more patients [19]. This view is also consistent with the traditional profit-maximization model of hospital behavior, which predicts that a reduction in price will lead to a reduction in quality [3]. However, the profit-maximization model might not adequately describe a hospital's decision making because a high proportion of hospitals are organized as not-for-profit institutions. Therefore, as described in Newhouse's [21] theory of nonprofit behavior, hospitals use the excess of payments over costs for those patient groups that are profitable to expand the quality of services [20, 21].

Based on our findings, the share of positive associations between cost/price and the quality of care is higher when process rather than outcome measures are assessed. Process measures might be more sensitive to changes in a hospital's cost/price and more reflective of the factors under the hospital's control than outcome measures [22]. Moreover, changes in process measures might affect the hospital cost. For example, providing appropriate care frequently requires additional physician visits and medications [23].

Regarding our findings, the share of positive associations between cost/price and the quality of care is higher when the focus is on AMI, CHF, and/or stroke patients (instead of patients with other clinical conditions or all patients). Notably, in contrast to many other conditions, AMI, CHF, and stroke are emergency conditions. For these conditions, the steering and organization of emergency pathways (e.g. centralization and telemedicine) lead to an increase in patients, and costs are higher due to 24/7 infrastructure and operation (contingency) costs. In this case, quality (particularly mortality measures) should also increase because of the volume/outcome relationship.

Based on our findings, the share of positive associations between cost/price and the quality of care is higher when the methodological approach used to address confounding is more advanced. Endogeneity is clearly an issue in the price/cost-quality relationship, e.g. due to the high risk of omitted variable bias (e.g. insufficient risk adjustment, unobserved variations in hospital equipment and organization of service provision). If methods that more appropriately rule out endogeneity bias find stronger support, this might imply that the other studies underestimate the true effect.

Table 3 Overview on study findings on the price-quality relationship in total and for different subcategories

	Sign linear positive (*n*) (% of ni)	Sign linear negative (*n*) (% of ni)	Not sign (*n*) (% of ni)	Total (ni) (% of 60)
Total price/reimbursement	22 (37%)	7 (115%)	31 (515%)	60 (100%)
Quality of care measure				
Outcome	**16 (30%)**	**7 (13%)**	**21 (39%)**	53 (88%)
Mortality	16 (40%)	4 (10%)	20 (50%)	40 (67%)
Readmission	0 (0%)	0 (0%)	1 (100%)	1 (1%)
Complication/morbidity	0 (0%)	3 (25%)	9 (75%)	12 (20%)
Process measures	**6 (86%)**	**0 (0%)**	**1 (14%)**	7 (12%)
Stroke process measure	6 (86%)	0 (0%)	1 (14%)	7 (12%)
Clinical conditions				
AMI	4 (67%)	0 (0%)	2 (33%)	6 (10%)
CHF	2 (67%)	1 (34%)	0 (0%)	3 (5%)
Stroke	9 (75%)	0 (0%)	3 (25%)	12 (20%)
Pneumonia	0 (0%)	1 (34%)	2 (66%)	3 (5)
Hip fracture/replacement	1 (100%)	0 (0%)	0 (0%)	1 (15%)
Other surgical procedures	4 (57%)	3 (43%)	0 (0%)	7 (115%)
Other medical conditions	2 (85%)	2 (85%)	20 (83%)	24 (40%)
Not available conditions	0 (0%)	0 (0%)	4 (100%)	4 (7%)
Country				
Germany	1 (100%)	0 (0%)	0 (0%)	1 (2%)
Japan	6 (60%)	0 (0%)	3 (40%)	9 (15%)
USA	15 (30%)	7 (14%)	28 (56%)	50 (83%)
Year				
1990–1999	1 (4%)	3 (11%)	22 (85%)	26 (43%)
2000–2009	0 (0%)	0 (0%)	4 (100%)	4 (7%)
2010–2018	21 (70%)	4 (13%)	5 (17%)	30 (50%)
Methods				
CfO a multivariable model (cross-section)	6 (67%)	0 (0%)	3 (34%)	9 (15%)
CfO b multivariate model	9 (21%)	7 (16%)	27 (63%)	43 (72%)
CfU—IV approaches	7 (875%)	0 (0%)	1 (125%)	8 (13%)

CfO controlling for observables, *CfU* controlling for unobservables, *IV* instrumental variable

During our analysis, we observed that only a small share of studies tested for a nonlinear cost-quality relationship. Among these studies, U-shaped/inverted U-shapes relationships were assessed mostly in studies using more advanced econometric methods (e.g. the IV approach) and those concentrating on hip fracture/replacement conditions.

The current systematic review is subject to several limitations. First, the heterogeneity in the studies' criteria limited our ability to perform a quantitative synthesis or any other comparisons across the studies. In addition, this review was limited by the quality of the included studies. Moreover, there is a possibility of publication bias because no gray literature was searched, and non-English language publications were excluded.

Although our study may answer important questions regarding the association between cost/price and the quality of care, other related questions may remain unanswered. Given our findings, we observed some differences in the associations between surgical and medical conditions. Future work could explain the reason for these differences. Additionally, we focus on several critical design characteristics that may alter the association between cost/price and the quality of care; however, some other characteristics, such as market characteristics (e.g. competition), might be able to explain some differences in the cost/price-quality relationship.[2] For example, hospitals with a large number of beds relative to the population size might have more competition for nurses, which increases labor costs [24]. This review also suggests that more research is needed to generate robust evidence regarding the association between cost/price and the quality of care.

In conclusion, our review suggests that there is no general relationship between cost/price and the quality of care.

[2] None of the included studies controlled for such covariates.

However, when accounting for endogeneity, the evidence suggests that a positive relationship exists. Additionally, the relationship appears to depend on the condition and the specific resource utilization. Thus, the potential to increase the quality of care while maintaining or reducing the price and cost levels is low for several conditions, while for other conditions, the evidence is inconclusive. Moreover, different countries/regions have different regulations for quality assurance (e.g. staffing regulation, mortality and morbidity-conferences, technology use, and minimum volumes), which clearly has an effect on cost and quality. Therefore, policy makers should be prudent with the measures used to reduce hospital costs to avoid endangering the quality of care, especially in resource-sensitive settings.

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Author Contributions VW and SJ conceptualized and wrote the manuscript, which was critically reviewed and extended by JS; the data extraction protocol was drafted by SJ; and the validation of the data extraction (tables) was performed by SJ and VW. All authors discussed the results and contributed to the final manuscript, and all authors approved the manuscript.

Data Availability Statement The authors confirm that all relevant data are included in the article and/or its supplementary information files.

Compliance with Ethical Standards

Conflict of Interest Sara Jamalabadi, Vera Winter, and Jonas Schreyögg declare that they have no conflicts of interest.

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