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L. Di Giorgio, M. Filippini, G. Masiero

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L. Di Giorgio ^{*} M. Filippini [†] G. Masiero [‡]

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Abstract

We investigate the relationship between costs and quality in nonprofit nursing homes, a key issue in the present context of cost containment measures. In accordance with the economic theory of production, we estimate a three-inputs total cost function for nursing home services using data from 45 nursing homes in Switzerland between 2006 and 2010. Quality is measured by means of clinical indicators regarding process and outcome derived from the Minimum Data Set. We consider both composite and single quality indicators. Contrary to previous studies, we use panel data and control for unobserved heterogeneity. This allows to capture nursing homes specific features that may explain differences in structural quality or costs levels. We find evidence that poor levels of quality regarding outcome, as measured by the prevalence of severe pain and weight loss, lead to higher costs. Our results are robust to quality endogeneity concerns.

Keywords: nursing home costs, nonprofit, quality indicators, cost-quality tradeoff

JEL classification: I10, L3.

^{*}Institute for Health Metrics and Evaluation (IHME), University of Washington, United States; Institute of Economics (IdEP), Università della Svizzera italiana (USI), Switzerland. Corresponding author. E-mail address: lauradg@uw.edu. We thank Andrew Street for helpful comments and invaluable advice during my stay with the Policy team at the Center for Health Economics at the University of York. Also, we thank the Swiss National Science Foundation for financial support to the project. Any mistake is clearly our fault.

[†]Institute of Economics (IdEP), Università della Svizzera italiana (USI); Swiss Federal Institute of Technology in Zurich (ETHZ), Switzerland.

[‡]Department of Engineering, University of Bergamo, Italy; Institute of Economics (IdEP), Università della Svizzera italiana (USI), Switzerland.

1 Introduction

Ensuring good quality of care to nursing home (NH) residents is a major concern in many health care systems. Actions to boost quality must take into account cost containment measures required to manage increasing health expenditures and ageing population. This twin objective of the NH sector - high quality and affordable costs - calls for better understanding of the potential trade-off between costs and quality. Quality aspects need to be integrated in the empirical evidence of NH costs.

The literature on NH costs is extensive, but marginally addresses quality of care. Most of the studies do not include measures of quality. Some of them use imprecise or indirect measures, such as the number of deficiency citations, information about staffing or mortality rates. Others rely on modeling quality as a latent variable (Gertler and Waldman, 1992; Carey, 1997). Finally, the majority of these studies use cross-sectional designs and do not account for unobserved heterogeneity that may affect both costs and quality. Concerns arise because failure to account for quality in cost functions is responsible for omitted variable bias (Braeutigam and Pauly, 1986). This bias is even more severe when comparing individual efficiency levels, as these techniques are particularly sensitive to model misspecification (Newhouse, 1994; Cremieux and Ouellette, 2001).

Donabedian (1988) conceptualizes the measurement of quality in the NH sector in terms of three dimensions: Structure, Process and Outcome (SPO). The SPO framework is widely accepted in empirical analyses of quality. Inability to include information about these three dimensions of care are due to measurement deficiencies and limitations in data availability. Recently, the introduction of the Resident Assessment Instrument (RAI) in the U.S. and some European countries, started a comprehensive and multidimensional assessment of all NH residents health status. These data, also called Minimum Data Set (MDS), are used to develop a battery of clinical indicators of quality that meet the taxonomy of the SPO model (Zimmerman, 1995; 2003). These indicators are categorized in two groups: indicators of quality regarding process and indicators of quality regarding outcome of care. As such, they offer a unique tool to measure and compare quality of NHs in different domains of care (Berg et al., 2012). However, NH cost studies using clinical quality indicators generally neglect the relationship between differ-

ent quality dimensions. More effort is needed to understand whether the multidimensional nature of quality is better captured by single or combined quality indicators.

A positive relationship between costs and quality is generally expected when higher levels of quality can be provided only through more costly equipment or additional staff employment. However, adverse patient events may be costly to treat because they involve additional resource utilization for extra care. The relationship between costs and quality may therefore depend on the dimension considered. Better procedures are expected to increase costs, while prevention of development of adverse outcomes may actually reduce costs (Weech-Maldonado et al., 2006; Wodchis et al., 2007).

Through this paper, we investigate the relationship between quality and costs in NH care and contribute to the existing literature in four main respects. First, we use a cost function approach consistent with the economic theory of health care production. Second, we incorporate quality measures into the cost function based on the taxonomy of the SPO model, and disentangle the impact of different dimensions of quality on costs. Third, we conduct our analysis using both composite and single measures of quality. Finally, to our knowledge, this is the first study providing evidence on the relationship between costs and quality in NH care using panel data, if we exclude the approach by Wodchis et al. (2007) which does not specify a cost function.

The remainder of the paper is organized as follows: Section 2 outlines how quality for NH services can be measured and presents the SPO framework more in detail. Section 3 reviews previous studies on the relationship between costs and quality. Section 4 describes the dataset and discusses the choice of quality indicators and the empirical strategy. Estimation technique and results are presented in Section 5. Finally, some concluding remarks are provided in Section 6.

2 Quality

2.1 Definition and measurement

No universal definition of quality exists in health research. The Institute of Medicine (IOM, 2001) states that “quality of care is the degree to which

health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge”.¹ This definition has significantly influenced the literature on quality and is very much related to the paradigm of quality proposed by Donabedian (1988). His seminal article on the assessment of quality of care represents the foundation of modern quality assessment, providing a framework of reference with guidance validity. Donabedian proposed the so called SPO framework. Structure is defined by the attributes of the setting in which care is provided, such as material resources (e.g. equipment), human resources (e.g. staffing levels) and organizational structure (e.g. payment system). Process refers to the activities of practitioners to give care, such as making a correct diagnosis and implementing the treatment accordingly. Outcome defines the change in health status of the patient. The success of this paradigm lies in its broad scope, which encompasses older and newer definitions of quality. Table 1 shows how different measures of quality used in the literature fall within the dimensions of the SPO framework.

With the development of quality indicators derived from the RAI, clinical measures of quality regarding process and outcome are now available. However, only a few countries have adopted the RAI. Many countries use different systems to measure quality in the NH sector (Nakrem et al., 2009). Each measure of quality has advantages and disadvantages, which are discussed below. Some relatively old indicators (non-clinical) are still considered valid and are often combined in empirical studies with clinical quality indicators derived from the RAI.

Previous studies attempt to capture NH quality differences mainly using indicators of structure or indirect signals. Probably, the most recognized indicator with current validity is the number of deficiency citations (Castle and Ferguson, 2010). Deficiency citations have the advantage of representing different dimensions of reduced quality but suffer from detection bias due to high variability in the use of citations among states/countries. Another important indicator that is employed extensively in the literature is the use of resources, in particular, information on staffing. While earlier studies focus

¹Other well recognized definitions are provided by the UK Department of Health (1997), the Council of Europe (1997), and the WHO (2000). For a detailed exposition of the most influential and known definitions of quality, see Legido-Quigley et al. (2008).

on staffing levels as determinant factors (McKay, 1989; Farsi et al., 2005; Farsi et al., 2008), recent studies recognize the need to extend this dimension to staff characteristics, such as staff turnover, worker stability and skill levels (Castle and Engberg, 2005; Castle and Engberg, 2007; Dormont and Martin, 2012; Spilsbury et al., 2011), as well as willingness of leadership (Rantz, 2004). A recent systematic review of Bostick et al. (2006) shows not only evidence of association between higher licensed staff and quality, but also a significant relationship between staff turnover and quality indicators such as pressure ulcers, weight loss and functional ability.

2.2 Concerns about quality indicators

The advantages and disadvantages of quality indicators based on the SPO model are discussed in Castle and Ferguson (2010). Structural indicators have the advantage of being easy to measure and data are often available. The disadvantage is that the presence of structural attributes does not imply their best use. Castle and Ferguson (2010) maintain that structural quality indicators are necessary but not sufficient. Indicators of process are usually easy to interpret as they inform on the provision of a particular treatment. Even in this case, it cannot be determined whether or not the provided treatment is appropriate. Finally, outcome indicators are of natural interest, as they measure the change in patients' health status. The main problem with these indicators is that it is extremely difficult to isolate the effect of care and changes in health, as the latter may be influenced by many uncontrolled factors.

The recent development of clinical quality indicators has improved the measurement of quality, but with some limitations. Firstly, due to the absence of a universally accepted definition of quality, the selection of quality indicators to include in empirical analyses is, to some extent, arbitrary. This is an issue because of the usually low correlation among quality indicators. Indeed, facilities with excellent outcomes in some dimensions may perform poorly in others. The choice of indicators may therefore affect the perception of NH quality. Secondly, detection bias occurs if higher quality NHs are the more vigilant in looking for and detecting quality issues (Mor et al., 2003). Since NH staff rather than an independent authority assesses residents health status, risk of detection bias exists. Thirdly, variation in clinical qual-

ity indicators may be due not only to changes in quality, but also in risk or error (Arling et al., 1997). To cope with this issue, different risk-adjustment techniques are used. While first studies of NH quality mainly use adjustment methods at the facility level (Nyman, 1988; Zinn et al., 1993a; 1994), more recently risk-adjustment is performed at the individual level when data are available. Different approaches include stratification, covariate models (Mukamel, 1997) and standardization (Zinn et al., 1993b). For some clinical indicators of quality that are considered particularly relevant in detecting the presence of problematic cases of quality shortcomings, no risk-adjustment is required. Among these are the presence of daily physical restraints (Berg et al., 2002), dehydration and fecal impaction (Arling et al., 1997; Karon et al., 1999). The main issue of risk-adjustment techniques is that they may only partially capture residents risk factors, resulting in biased estimates of quality coefficients (Mukamel et al., 2008). Risk-adjustment is also of concern when risk-adjustment factors are themselves a function of quality. In these cases, quality scores could be over-adjusted, giving credit for poor quality (Mukamel et al., 2008).

3 Empirical evidence on the impact of quality on costs

Empirical models using non-clinical quality measures mainly focus on the impact of specific factors on costs, such as market structure, forms of organization, or reforms implemented in the NH sector. Quality measures are usually introduced as control factors. Some of these studies use staffing information (e.g. Di Giorgio et al., 2014; Dormont and Martin, 2012; Farsi et al., 2008; Konetzka et al., 2004) or deficiency rates (e.g. Harrington et al., 2001). Another strand of literature exploits determinants of quality variability. Factors considered include the impact of state regulations (Bowblis et al., 2012; Bowblis and Lucas, 2012), ownership form (Grabowski et al., 2013; Spector et al., 1998), competition (e.g. Brekke et al., 2010; Castle et al., 2008; Forder and Allan, 2011; Grabowski, 2004; Starkey et al., 2005) and financial performance (Gutacker et al., 2013).

We focus our review on studies that use clinical indicators derived from the RAI to investigate the relationship between costs and quality. The main

contribution of these studies is summarized in Table 2, where details on the choice of quality indicators, the empirical approach and the results are presented.

Mukamel and Spector (2000) is one of the first studies investigating the relationship between costs and quality using the RAI-derived quality indicators. The authors estimate a variable cost function for NHs in New York State. Three indicators of outcome quality are included: activity of daily living, pressure ulcers and mortality. Regression-based risk adjustment (Mukamel, 1997) is applied and weighted ordinary least-squares are used to tackle the issue of different sample size in the calculation of outcome variables.² The authors report an inverted U-shaped relationship between costs and quality, although only few coefficients are statistically significant. The loss of statistical significance is attributed to high multicollinearity among higher-order terms of quality indicators. Due to the availability of only weak instruments, the endogeneity issue of quality is ignored.

An important contribution to the cost-quality relationship is provided by Laine et al. (2005a, 2005b) who implement stochastic frontier models. In these studies, endogeneity of quality is not addressed. The first study models a stochastic production frontier for the Finnish long-term care sector in 2001 where the dependent variable is specified as the case-mix weighted patient days and covariates include only input characteristics. Ward characteristics and quality are modeled following Battese and Coelli (1995), i.e. technical inefficiencies are specified as a function of quality indicators. Quality is measured linearly by three continuous indicators: the prevalence of high-risk pressure ulcers, the prevalence of weekly use of depressants and hypnotics, and the prevalence of depression with no treatment. The latter two indicators are not risk adjusted. The prevalence of pressure ulcers is the only quality indicator significantly associated with technical inefficiency. The suggested relationship is that higher prevalence of pressure ulcers leads to higher technical efficiency.

Laine et al. (2005b) provide a similar cross-sectional analysis which shifts the focus from productive efficiency to cost efficiency. The analysis is performed using data at the ward level obtained aggregating individual-level data. The authors include quality indicators regarding process, i.e. the

²The authors use the inverse of the squared root of the sample size as weights.

prevalence of depression without treatment and prevalence of pressure ulcers adjusted for risk, in the deterministic part of the cost frontier. Indicators of output quality, i.e. the prevalence of depressants and hypnotics use and the prevalence of restraint use, are modeled following Battese and Coelli (1995). The mean values of the indicators over a three-years period is taken without risk adjustment. The underlying idea is to allow indicators of process quality to affect the production process itself, while the outcome is restricted to have an impact on the level of inefficiency. The results show that a worse outcome in terms of higher prevalence of pressure ulcers is associated with higher costs, while poor process quality measured by the weekly use of depressants and hypnotics is associated with higher inefficiency. However, the impact of these quality indicators is relatively low.

Weech-Maldonado et al. (2006) investigate the impact of quality on costs in U.S. NHs. Using cross sectional data from around 750 facilities, they test the inverted U-shaped theory by adding squared and cubic terms of quality. Quality is measured by changes in physical and psychological outcome indicators, i.e. worsening pressure ulcers and mood decline. Indicators are adjusted for risk using the covariates model (Mor et al., 1998). A weighted two-stage least squares regression is estimated to address endogeneity of quality indicators. Socio-demographic characteristics at the county level as well as the presence of alternative service providers are used as instruments for quality scores. However, the validity of these instruments is not tested. The results show an inverted U-shaped relationship between costs and pressure ulcers. An opposite pattern arises for mood decline, showing that different indicators of quality may lead to different types of relationships.

Additional evidence based on data from Ontario, Canada, is provided by Wodchis et al. (2007). The authors estimate individual-effects models where total costs are regressed on output, labor price, some exogenous variables and quality indicators adjusted for risk using a resident-level covariates model.³ Heteroskedasticity, autocorrelation and endogeneity issues are discussed. However, due to the lack of a valid instrument, endogeneity is ignored. The analysis shows a negative relationship between costs and use of daily physical restraints, as well as worsening incontinence. Antipsychotic use, the prevalence of pressure ulcers and the prevalence of severe pain are

³As an exception the prevalence of physical restraint use is not risk adjusted.

not statistically significant.

Most of the studies presented above find correlation between some quality indicators and costs. However, the association is weak and the approaches used are hardly comparable. As suggested in the Introduction, the majority of these studies use a cross-sectional design and do not account for unobserved heterogeneity that may affect both costs and quality. The only exception is the study by Wodchis et al. (2007). Unobserved heterogeneity may represent a serious problem in analyses of costs-quality relationship due to the difficulty in measuring quality. If the risk-adjustment technique used in cross-sectional studies does not capture the facility-specific features perfectly, then the results may be biased. Also, only few studies address the potential endogeneity of quality, and virtually no test is provided on the validity of the instruments.

In the following section we propose an empirical approach to investigate the relationship between costs and quality using data from Swiss NHs. The main novelty of this approach is the inclusion of process and outcome quality measured by composite or single quality indicators into a cost function. As compared to previous studies, we are also able to control for unobserved heterogeneity by exploiting the panel structure of our data.

4 Model specification and data

4.1 Choice of quality indicators

Quality indicators measure adverse events such as the use of antipsychotic drugs, injuries, bedfast residents, and pressure ulcers. To select appropriate quality indicators from the 22 available in our dataset we consider two approaches. The first approach combines quality indicators to obtain composite measures of process and outcome quality, which are then plugged into a cost function. The second approach is based on the selection of single quality indicators of process and outcome directly included in the cost function. Clearly, both approaches have advantages and disadvantages.

Combining different quality indicators, as suggested for instance by the U.S. Institute of Medicine (2006), allows us to condense the multidimensional nature of quality, limit the number of variables included in an econometric model, and overcome possible arbitrariness in the choice of quality indica-

tors. Though, combining different quality indicators requires a weighting mechanism, which is subject to critics. Differences in the number of eligible residents for different quality events across facilities may represent a serious problem in obtaining a composite measure of quality. To overcome this problem, quality indicators can be adjusted before aggregation to increase comparability across facilities. The avoidable number of residents potentially exposed to different quality events may offer a valid solution for adjustment. A slightly more sophisticated approach relies on the generation of adjusted indicators using a principal component analysis (PCA). Still, composite measure of quality makes it difficult to identify the factors affecting costs. To address this issue, we rely on Donabedian’s classification of quality and derive separate composite indicators for both process and outcome. This allows us to identify the effect of the two quality dimensions separately.

To derive composite indicators of process and outcome quality ($Q_{process}$ and $Q_{outcome}$) we use two methods. First, we weight each quality indicator by the number of residents exposed to a given quality event within each NH. The second approach applies a principal component analysis using all quality indicators to obtain two composite measures of process and outcome quality.⁴ This statistical procedure accounts for possible correlation between different quality indicators through an orthogonal transformation which obtains values of linearly uncorrelated quality indicators called principal components. Each succeeding component has the largest possible variance in the data. We look at the second principal component to get adjusted quality indicators which are then aggregated to derive composite measures of process and outcome quality.

As stated above, the second approach to select appropriate quality indicators is based on single quality indicators. Single quality measures are probably more reliable and meaningful than composite measures. However, a selection process is needed to limit the number of indicators used in an econometric model. Our selection process is built on three strands of literature. First, we consult the medical recommendations on the pertinence of the indicators to reveal quality issues in NHs. Second, we consider studies on the

⁴The large majority of our quality indicators include 173 observations. However, for few of them information was collected only for two years. To maximize the number of observations used in the following econometric analysis, we dropped four single quality indicators with missing values (see Table 4 for details).

technical requirements that quality indicators need to satisfy to be included in empirical analyses. And finally, we look at previous studies investigating the relationship between costs and quality using the quality indicators analyzed by Zimmerman (1995).

From the medical literature we consult the numerous lists of recommended indicators to use in benchmarking analyses of NHs (Berg et al., 2002; Mor et al., 2003; Rantz et al., 2004). From the medical-statistical literature, we derive three main criteria that should be satisfied for the empirical analysis (Berg et al., 2002; Laine et al., 2005b): a relatively large variation in the quality scores, the absence of multicollinearity between the indicators and other variables, and a relatively large number of observations from which the quality indicators are calculated. The issue of the denominator is motivated by statistical properties since some quality indicators capture the onset of rare events. In these cases, the relevant question is whether the observed frequency of the event can be considered as a “true score”, or it is driven by random shocks. Indeed, standard errors of rare events are large and generate problems in the comparison of quality among facilities. The minimum number of observations for benchmarking is twenty (Berg et al., 2002).

Based on these criteria, we select two process quality indicators and two outcome quality indicators. The two indicators of process are the presence of antipsychotic use for low-risk residents (Q_{antips}) and the presence of daily physical restraints use (Q_{restr}). The two indicators of outcome include the prevalence of weight loss (Q_{weight}) and the prevalence of severe pain (Q_{Pain}). Finally, we control for time-invariant quality aspects regarding the structure of NHs through the econometric specification of the model (see section 5).

4.2 Detailing the cost function

In order to identify the impact of quality on costs, we consider a cost model which includes quality indicators as derived in section 4.1. Total costs are a function of output (Y), measured by the number of patient-days of NH care, prices for labor, capital and material (P_l , P_k , P_m), the institutional form of the NH (IF), the case-mix of residents (MIX), the nursing staff ratio (SR), a vector of process and outcome quality indicators (q), and a time trend (τ)

which captures technological progress:⁵

$$C = f(Y, P_l, P_k, P_m, IF, MIX, SR, \mathbf{q}, \tau). \quad (1)$$

The price of labor is calculated as the weighted average wage of different professional categories employed in the NH (doctors, nurses, administrative and technical staff). We choose to include only one price of labor to avoid multicollinearity problems that typically arise with labor prices for different categories. The price of capital is calculated as the sum of mortgage costs, amortization and costs related to capital purchases divided by the capital stock, which is approximated by the number of beds. The price for material and meals is computed by taking the remaining costs and dividing them by the number of meals provided each year. This item mainly includes costs for food, energy and administrative costs.

The main difference among nonprofit NHs lays in their institutional form. *Public-law* NHs are public administrative units without a separate judicial status from the local public administration. Conversely, *private-law* NHs usually take the form of a foundation. Since the decision-making process may vary across institutional forms, we include a dummy for the institutional form (*IF*) equal to one when the NH is a *public-law* organization, and 0 otherwise.

SR is the nursing staff ratio, i.e. the ratio between the number of nurses employed in a NH and the number of nurses that should be employed according to the guidelines of the regulator (optimal amount of staff). Because nursing care is a labor-intensive service, staffing levels have been recognized as a good indicator for (structure) quality (Bostick et al., 2006). Note, however, that our indicator is conceptually different from other quality indicators related to staff levels since it captures deviations from the optimal number of nurses.

The vector of process and outcome quality indicators (q) leads to three different model specifications. In Model 1, the quality vector includes two composite indicators ($Q_{process}$ and $Q_{outcome}$) derived from PCA. Similarly, in Model 2 the quality vector is represented by two composite indicators derived using weights according to the number of residents exposed to different

⁵In a non-competitive environment such as the Swiss one, there is no reason to assume that NHs minimize costs. In this case, the estimated costs function is a “behavioral cost function” (Evans, 1971) and can still be used to make a comparison among firms.

quality aspects. Finally, Model 3 includes a vector of 4 single quality measures: two process quality indicators - the prevalence of antipsychotic use for low-risk residents (Q_{antips}) and daily physical restraints use (Q_{restr}) - and two outcome quality indicators - weight loss (Q_{weight}) and severe pain (Q_{pain}).

Q_{antips} is risk-adjusted based on the stratification approach, whereas Q_{restr} is a sentinel indicator and as such no risk-adjustment is required (Berg et al., 2002). Due to lack of data at the resident level, we further control for case-mix differences using an index at the facility level (MIX). This index measures average patients' assistance need by means of normal daily activities such as eating, personal care or physiological activities and is calculated on yearly basis by the regulator. Patients are classified in one out of five categories according to their severity level. A value between 0 and 4 is assigned where higher values indicate more severe cases.⁶ We expect this case-mix indicator to be correlated with patients' risk factors that are not observable. Moreover, any unobserved facility-specific risk factors feature is captured by the individual effects. We acknowledge that the risk-adjustment system used in this analysis may be less precise than adjustments based on clinical information at individual level. However, as previously discussed, even complex systems of risk adjustments present serious shortcomings.

For the estimation of the cost model in (1), we use a log-log functional form. This implies that cost elasticities are not allowed to vary with output. When choosing the functional form, parsimony in the number of coefficients to be estimated is traded off against flexibility. A translog functional form would require interacting all quality indicators with the production factors. The number of parameters to be estimated would expand to $(n+1)(n+2)/2$, where n is the number of covariates, leading to an important loss of degrees of freedom.⁷

Input prices and total costs are divided by the material price in order to

⁶Note that this is not the RUG's classification system of residents. As compared to the RUGs system, our case-mix measure is not derived from the MDS. The main advantage is that case-mix differences are less likely to reflect quality levels.

⁷In a preliminary analysis, we also estimated: 1) a full-translog cost model and 2) a hybrid translog cost model. In the hybrid translog cost function quality indicators were included only in linear form. The results of the full translog were not satisfactory, probably due to multicollinearity problems and the loss of degrees of freedom. The results of the hybrid cost function were very similar to those obtained with the log-log functional form.

satisfy the homogeneity condition in input prices.⁸ The log-log form of eq. (1) is:

$$\ln\left(\frac{C}{P_m}\right) = \delta_0 + \delta_Y \ln Y + \delta_{P_l} \ln \frac{P_l}{P_m} + \delta_{P_k} \ln \frac{P_k}{P_m} + \delta_{IF} IF + \delta_{MIX} \ln MIX + \delta_{SR} SR + \boldsymbol{\delta}_q \mathbf{q} + \delta_t \tau + \varepsilon, \quad (2)$$

where $\boldsymbol{\delta}_q$ is the vector of quality parameters, ε is the error term which contains individual effects δ_i . The individual subscript i and the time subscript t are omitted for simplicity.

The estimation of the cost function in (2) is based on the assumption that output, input prices and quality are exogenous variables. In the case of NHs included in the sample, output is likely to be exogenous because NHs have to accept all residents in a given residential area and residents do not have free choice of the facility. Also, the excess of demand due to subsidized prices leads to occupation rates of about 100%. For the same reasons, also the case-mix is likely to be exogenous. Moreover, the reimbursement system is linked to the NH-specific case-mix, which limits incentives to attract less costly patients. Input prices can be considered exogenous because NHs have to follow the guidelines imposed by the regulator.

As with respect to quality, it is important to distinguish between the nursing staff ratio and clinical quality indicators derived from the RAI. The nursing staff ratio is strongly regulated by the canton and NHs are not allowed to deviate significantly from the optimal staff size. Therefore, we can exclude the presence of endogeneity.⁹ The potential endogeneity issue of unregulated clinical indicators will be discussed later in section 5.

4.3 Data and descriptive statistics

We merge two datasets on costs and quality of NH residents in Southern Switzerland (canton of Ticino), which were provided by the regulator. The first dataset includes yearly use of resources at the organization level extracted from the annual reports of NHs. It includes 45 NHs over a 10-years

⁸The cost function is linear homogenous of degree 1 in input prices when a 10% increase in all input prices leads to a 10% increase in total cost.

⁹The Durbin-Wu-Hausman test performed using the lagged SR as instrumental variable does not reject exogeneity at the 99% level.

period, from 2001 to 2010. The second dataset contains information derived from the MDS on 22 quality indicators at the organization level for the period 2006-2010, excluding the year 2008. These indicators measure the presence of adverse events in the facility.¹⁰ Due to missing values in the dataset, no quality scores are available for three NHs for the years 2006 and 2007. Complete data pertaining to 45 NHs observed over a 4-years period (2006, 2007, 2009 and 2010) are used. The total number of observations is 173 for the models with composite quality indicators. For the model with single quality indicators we exclude observations with denominator of the quality scores smaller than 20. This leads to a loss of 10 observations.

In tables 3 and 4 we provide descriptive statistics for the main costs and quality variables. The data show that on average a resident day costs 247 Swiss francs (SFr.). The difference between the minimum and the maximum cost is almost SFr. 200. This may be due to differences in the output, as the number of resident days ranges between almost 9000 and more than 64000. The average resident case-mix is 3.1, with important differences among NHs (0.80-3.83). The average price of labor is approximately SFr. 81000, and NHs are highly homogenous in this respect. The prices of capital and material show higher variation, from SFr. 1054 to almost SFr. 23000 and from SFr. 5.16 to around SFr. 103, respectively. These differences are due to renovation or enlargement investments. At the approximation point, the shares of capital, material and labor costs are 6.5%, 12.1% and 81.4%, respectively.

Regarding quality indicators, the data show that the nursing staff ratio is very close to 1, as expected. Variations larger than 10% are possible only for very short periods. On average, 32% of low-risk patients use antipsychotics, but in some NHs this value reaches 88%, suggesting that serious problems may exist within the production process of NH care. The average prevalence of daily physical restraints use is around 20%, and ranges between 0 and 50%. Regarding outcome quality, the average prevalence of residents who lost weight unexpectedly is about 7%, and this percentage ranges between 0 and 27%. Finally, the prevalence of residents suffering from severe pain is 21% on average, but reaches more than 60% in some cases.

¹⁰Four of these indicators are risk adjusted based on the stratification approach. This means that they are calculated separately for high-risk and low-risk patients. In these cases, we use the low-risk indicators.

An interesting question is whether quality domains are correlated. This may affect the selection process of appropriate composite quality scores as well as the choice of single quality indicators to be included in the econometric analysis. We compute the correlation among indicators (including the staff ratio) and Kendall’s rank correlation coefficient (Kendall, 1955). The latter measures the similarity of the ordering of NHs when these are ranked according to quality scores. Both measures indicate a very low correlation between quality indicators ($< 25\%$). Furthermore, we are confident that the derivation of composite quality indicators using orthogonal components (Model 1) and the selection process of a small number of single quality indicators (Model 3) explained in section 4.1 ensure that collinearity between quality scores is not an issue in our regressions.

5 Econometric estimation and results

To analyze the impact of process and outcome quality on costs we use panel data models. The FE model treats the individual effects as fixed parameters. These are allowed to be partially correlated with regressors, thus accommodating a limited form of endogeneity (Cameron and Trivedi, 2010). This feature is particularly appealing in studies of costs-quality relationship due to the potential endogeneity of the indicators. The Hausman test rejects the null hypothesis of no correlation between the individual-effects and the covariates at 5% significance level. Given that the percentage of within variation of the variables of interest as with respect to the overall variation is satisfactory, the FE estimates should be fairly precise (Cameron and Trivedi, 2005). Therefore, the FE model represents our preferred estimator. The results of the estimation of the three models with combined and single quality indicators described in section 4.2, are reported in Table 5.

Standard errors are corrected using the cluster-robust estimator based on Stock and Watson (2006) in all models. These authors show that the cluster-robust estimator is preferred in FE models if serial correlation is expected, and it is reasonable to rely on asymptotic theory. In our sample, each cluster contains a sufficient number of observations so that clustered standard errors are preferred (Kezdi, 2004).¹¹

¹¹Kezdi (2004) states that a sample of 50 clusters is close enough to infinity for accurate

The estimated parameters are very similar across the three models. The coefficient of output (Y) is positive and smaller than 1, suggesting that an increase in output by 10% increases total costs by roughly 7%. As expected, more severe patients (MIX) are more costly to treat. The share of labor costs (P_l) is estimated at around 91%, while the estimated share of capital (P_k) is between 6% and 7%. The form of organization (IF) is dropped in the FE regressions because of time invariance, whereas it does not seem to affect total costs in the OLS and the RE regressions.

Consider now the main variables of interest: quality indicators. The nursing staff ratio (SR) is highly significant. As expected, the higher the relative number of nurses working in a NH, the higher the costs. The estimated coefficient is stable across the three models. In Model 1 and Model 2, we consider two composite quality indicators ($Q_{process}$ and $Q_{outcome}$). Note that outcome quality exhibits a positive and significant effect on costs in both models although the magnitude of the effect is stronger when composite quality indicators are derived using weights according to the number of residents exposed to different quality aspects (Model 2). Conversely, process quality shows an opposite (negative) effect on costs, although the impact is not significant. These results are in accordance with those obtained with single quality measures (Model 3). We observe a positive and significant association between costs and outcome quality measured by the prevalence of weight loss (Q_{weight}) and the prevalence of severe pain (Q_{pain}). Instead, process quality measured by the use of daily physical restraints (Q_{restr}) and the prevalence of antipsychotic use for low-risk residents (Q_{antips}) does not seem to have a significant impact on costs. The former indicator (Q_{restr}) is, however, slightly associated with lower costs in OLS and RE regressions reported in Table 6.

The time trend (t) is statistically significant in Models 2 and 3 but the coefficient is very small. Total costs of NH care remained pretty constant over the time period considered in the analysis.

Generally, all the estimated parameters are very similar across different panel models, only slightly lower in the FE model. The OLS model does not

inference if the number of observations for cluster is not too small. A cluster is considered small if it contains less than five observations per cluster (Rogers, 1994). In our case, the significance of the coefficients remains unchanged when standard errors are clustered.

consider the unobserved heterogeneity. The similarity of the RE and the FE estimates suggests a low correlation between the individual effects and our covariates.

5.1 Testing for endogeneity

We believe that, even in the unlikely possibility of quality endogeneity, the potential bias in our estimates is very limited. This is because of the institutional setting of the NH sector and the strong regulation system. NHs activities are regulated by the local government in a relatively effective way. Therefore, we can plausibly assume that NHs do not vary their levels of quality according to the cost of services. Nonetheless, in order to test potential endogeneity, we consider instrumental variables approaches using the two-stage least squares (2SLS) procedure and the efficient generalized method of moments (GMM) combined with the FE model. The GMM approach has the advantage of consistency in the case of arbitrary heteroskedasticity and shows higher flexibility than 2SLS, in particular to test the validity of the instruments. Both approaches come at the price of poor finite sample performance, in particular in the case of weak correlation between the instruments and the endogenous variable.¹² The GMM approach is preferred since it allows errors clustering for panel data and provides a battery of tests to check the validity of the instruments.

A valid instrument must satisfy two requirements: the instrument z must be correlated with the endogenous variable x , $Cov(x, z) \neq 0$, and uncorrelated with the error term u , $Cov(z, u) = 0$. In the case of multiple endogenous regressors, the Shea partial R^2 (Shea, 1997) measure should be used to test the first condition, as this takes into account the intercorrelation among the instruments.¹³ However, this does not exclude the possibility of weak instruments, which lead to a very high asymptotic bias. The second condition can be tested when there are more instruments for an endogenous variable. In

¹²In particular, the efficient GMM approach may suffer from poor finite sample properties as the optimal weighting matrix of the efficient GMM estimator is a function of fourth moments, which require large sample size (Hayashi, 2000).

¹³The F diagnostic for weak instrument for the joint significance of the instruments in first-stage regression does not recognize situations in which some instruments are good while others are weak.

this case, the C-statistic, also called “difference-in-Sargan” statistic, can be used to test the orthogonality condition of a subset of instruments (Hayashi, 2000).

As shown in previous studies (Mukamel and Spector, 2000; Wodchis et al., 2007), good instruments for quality are lacking. Moreover, finding good instruments for several quality indicators is also very challenging. We rely on three hypotheses. First, visits by residents’ relatives exert pressure on the management staff of the NH to keep adequate levels of quality. Hence, we identify two variables: the weighted average distance (travel time) between residents’ location and the NH facility, and the weighted population density of the area served by the NH. The second hypothesis assumes that the quality offered by the NH depends on the average quality offered by surrounding NHs. We build a variable to capture pressure from other NHs located in geographical proximity. For each year and NH, pressure is measured as the average score of quality indicators of NHs located in neighbouring districts.¹⁴ Our third hypothesis is that the elderly population living in the area around the NH exercise an indirect pressure on quality of home care provided. We then consider the percentage of young, adult and elderly population in the catchment area of each NH. Finally, we also consider lagged values of quality indicators as natural instruments.¹⁵

Generally, our endogeneity tests do not reject exogeneity when using all or part of the instruments defined above both with composite and single quality indicators. However, the Shea partial R^2 statistics show that the percentage of variability in quality indicators explained by the instruments is relatively low. Since our instruments are likely to be weak we cannot be confident that the exogeneity of quality indicators is correctly assessed, and therefore the Hausman test may be distorted. However, as explained by Hahn et al. (2011), discussion about weak instruments is not completely clear in the econometric literature. As stated above, addressing endogeneity using

¹⁴The region considered in the analysis is divided into 8 districts: Mendrisio, Lugano, Vallemaggia, Locarno, Bellinzona, Riviera, Blenio and Leventina. Given that only few NHs are located in northern districts, Vallemaggia, Leventina and Blenio are pooled together.

¹⁵Lagged values are an attractive instrument due to the high correlation with the endogenous variable. Nevertheless, caution is necessary in the presence of serial correlation in the data, as this may invalidate the instruments (Angrist and Kruger, 2001). To test for autocorrelation in panel data set, we use the test developed by Wooldridge (Drukker, 2003; Wooldridge, 2002).

multiple quality indicators and many instruments may not be very efficient. Consequently, we test exactly identified models with only one quality indicator and one instrument. The null hypothesis that the excluded instruments are exogenous cannot be rejected in all these cases and the results are robust to weak identification. Although we are not able to econometrically exclude that quality endogeneity is completely absent in the relationship between costs and quality in NH care, we show evidence that our FE estimates are unlikely to be affected by quality endogeneity bias.

6 Conclusions

To ensure good quality of long term care while keeping costs under control, a better understanding of the relationship between costs and quality is needed. In the NH sector, quality improvements represent a main concern since the ageing of the population is putting the system under financial pressure.

In this paper, we investigated the relationship between costs and quality according to the SPO-framework developed by Donabedian (1988). We used recently published data on quality indicators derived from the resident assessment instrument (RAI) and costs of Swiss NHs. In addition to structure quality indicators (e.g. nursing staff ratio), we considered composite and single measures of process and outcome quality. Composite indicators of process and outcome quality were obtained by aggregating 22 single quality indicators using i) NH-specific weights based on residents exposed to different quality aspects or ii) a principal component analysis. Alternatively, a limited number of single quality indicators capturing process and outcome quality was selected.

To disentangle the impact of different dimensions of quality on costs, we incorporated quality measures into a cost function. As compared to previous studies, we estimated individual-effects models based on panel data that allowed to control for unobserved heterogeneity. Our analyses showed evidence of a positive and significant relationship between clinical indicators of outcome quality (e.g. the prevalence of severe pain and the prevalence of weight loss) and total costs. Conversely, the impact of process quality indicators was unclear. For instance, higher prevalence of daily physical restraint use was associated to lower costs, while the use of antipsychotics was positively related to costs, but these effects were only weakly significant. Finally, struc-

ture quality indicators such as staffing levels were strongly associated with higher costs. We did not find evidence of quality endogeneity bias.

From a policy point of view, a correlation between costs and quality may suggest that quality aspects should be incorporated in funding schemes designed for NH care. Accounting for this correlation may allow the regulator to refine economic incentives taking into account the trade-off between quality and costs.

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Structure	Process	Objective outcome	Subjective outcome
Room size	Staffing information	Mortality rates	Resident satisfaction
Equipment	Mistakes rate	Hospitalization	Family satisfaction
Staffing levels	Deficiency citations	RAI quality indicators	Deficiency citations
Residents case mix	RAI quality indicators		

Table 1: Classification of quality indicators according to the SPO-framework developed by Donabedian (1988).

Study	Quality indicators	Empirical strategy (Data)	Effects on costs
Mukaml and Spector, 2000	Incidence of functional decline Incidence of bedsores Mortality	Weighted least squares models (Cross-sectional data)	Inverted U-shaped Inverted U-shaped Inverted U-shaped
Laine et al., 2005a	Prevalence of pressure ulcers Prevalence of weekly use of depressants Prevalence of depression w/o treatment Prevalence of depression w/o treatment	Stochastic frontier models (Cross-sectional data)	Positive effects No significant effects No significant effects No significant effects
Laine et al., 2005b	Prevalence of pressure ulcer Prevalence of use of depressants Prevalence of use of physical restraints	Stochastic frontier models (cross-section)	Positive effects Positive effects No significant effects
Weech-Maldonado et al., 2006	Worsening of pressure ulcers Mood decline Prevalence of physical restraints Prevalence of use of depressant	Two-stage least squares models (Cross-sectional data)	Inverted U-shaped U-shaped Negative effects No significant effects
Wodchis et al., 2007	Prevalence of urinary incontinence Incidence of urinary incontinence Prevalence of skin ulcers Incidence of skin ulcers Prevalence of pain	Random and fixed effects models (Panel data)	Positive effects U-shaped No significant effects Negative effects No significant effects

Table 2: Overview of selected studies investigating the relationship between costs and quality in NHs.

Variable	Description	Obs	Mean	SD	Min	Max
C	Average cost (SFr./ Y)	440	246.90	25.66	179.48	377.52
Y	Annual resident days	519	25434	10231	8955	64275
P_l	Average labor price in SFr. per employee per year	519	80817	5196	63363	97512
P_k	Average capital price in SFr. per bed	440	5735	2528	1054	22981
P_m	Average material price in SFr. per meal	440	9.23	4.74	5.16	103.25
MIX	Average dependency index	519	3.10	0.34	0.80	3.83
SR	Nursing staff ratio	519	0.96	0.09	0.74	1.55

Notes: All monetary values are in 2005 Swiss francs (SFr.), adjusted by the national Consumer Price Index.

Table 3: Descriptive statistics of costs, output and structure variables.

Quality indicator	Description	Obs	Mean	SD	Min	Max
PROCESS						
$Q_{depressionNT}$	PR of depression symptoms without treatment	173	31.45	12.54	3.6	60.0
Q_{drugs}	Prevalence of use of 9 or more medications	173	41.46	14.30	0.0	75.0
$Q_{catheters}$	INC of indwelling catheters	173	5.38	5.25	0.0	27.9
Q_{gavage}	PR of enteral feeding	130	1.46	2.67	0.0	17.5
$Q_{antipsyHR}$	PR of antipsychotic use - HR	173	51.47	23.22	0.0	100.0
$Q_{antipsyLR}$	PR of antipsychotic use - LR	173	31.67	12.45	7.7	87.5
$Q_{restraints}$	PR of daily physical restraints	173	19.56	9.76	0.0	50.0
$Q_{activity}$	PR of little or no activity	173	52.73	19.74	6.7	100.0
$Q_{process}$	Composite indicator (using No. exposed)	173	25.83	5.01	12.9	40.3
	Composite indicator (using PCA)	130	0.00	1.15	-3.6	3.2
OUTCOME						
$Q_{injuries}$	INC of injuries	159	2.39	6.64	0.0	50.0
Q_{falls}	PR of falls	173	9.20	5.70	0.0	24.4
$Q_{behaviourHR}$	PR behavior problems - HR	173	34.44	13.80	0.0	78.9
$Q_{behaviourLR}$	PR behavior problems - LR	173	15.30	13.33	0.0	70.0
$Q_{depression}$	PR of depression symptoms	173	56.41	16.47	14.8	100.0
$Q_{incontinenceHR}$	PR of bowel incontinence - HR	173	80.23	19.86	0.0	100.0
$Q_{incontinenceLR}$	PR of bowel incontinence - LR	173	30.54	19.40	0.0	100.0
$Q_{incontinence}$	PR of bladder incontinence without a toileting plan	173	59.88	25.91	0.0	100.0
Q_{weight}	PR of weight loss	173	6.75	5.10	0.0	27.3
$Q_{bedfast}$	PR of bedfast residents	172	8.48	6.75	0.0	29.6
Q_{los}	Incidence of decline in late-loss activities of daily living	154	30.79	26.12	0.0	100.0
$Q_{ulcersHR}$	PR of pressure ulcers - HR	173	11.67	9.24	0.0	50.0
$Q_{ulcersLR}$	PR of pressure ulcers - LR	173	2.90	5.01	0.0	28.6
Q_{pain}	PR of important pain	173	21.24	11.99	0.0	61.1
$Q_{outcome}$	Composite indicator (using No. exposed)	173	17.68	4.08	6.8	28.6
	Composite indicator (using PCA)	153	0.00	1.16	-2.7	3.0

Notes: INC=incidence, PR=prevalence, HR=high-risk, LR=low-risk

Table 4: Descriptive statistics of process and outcome quality indicators.

	Model 1		Model 2		Model 3	
	Composite quality indicators		Single quality indicators			
	using PCA		using No. exposed			
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
<i>Constant</i>	-3.212***	0.470	-3.477***	0.505	-3.621***	0.541
<i>Y</i>	0.718***	0.038	0.736***	0.041	0.751***	0.046
<i>P_l</i>	0.907***	0.025	0.911***	0.025	0.916***	0.026
<i>P_k</i>	0.068***	0.015	0.067***	0.015	0.059***	0.015
<i>MIX</i>	0.203***	0.065	0.202***	0.064	0.219***	0.079
<i>SR</i>	0.464***	0.059	0.482***	0.066	0.480***	0.071
<i>Q_{process}</i>	-0.002	0.004	-0.048	0.070		
<i>Q_{outcome}</i>	0.006**	0.003	0.240**	0.094		
<i>Q_{antips}</i>					0.026	0.025
<i>Q_{restr}</i>					-0.064	0.042
<i>Q_{pain}</i>					0.056**	0.027
<i>Q_{weight}</i>					0.102**	0.043
<i>t</i>	0.003	0.002	0.006**	0.002	0.005***	0.002
<i>R</i> ²	0.977		0.977		0.980	
<i>N</i>	173		173		163	

Notes: Significance levels: * = 10%, ** = 5%, *** = 1%.

Table 5: Estimated coefficients of fixed effects models with composite and single quality indicators.

	Model 3 (Single quality indicators)			
	OLS		Random effects	
	Coef.	Std. Err.	Coef.	Std. Err.
<i>Constant</i>	-4.546***	0.439	-4.657***	0.328
<i>Y</i>	0.875***	0.017	0.853***	0.019
<i>P_l</i>	0.874***	0.040	0.910***	0.027
<i>P_k</i>	0.062***	0.015	0.059***	0.013
<i>IF</i>	-0.009	0.014	-0.007	0.015
<i>MIX</i>	0.277***	0.081	0.254***	0.060
<i>SR</i>	0.485***	0.089	0.513***	0.069
<i>Q_{antips}</i>	0.033	0.054	0.034	0.025
<i>Q_{restr}</i>	-0.119**	0.048	-0.071*	0.040
<i>Q_{pain}</i>	0.076	0.046	0.061**	0.028
<i>Q_{weight}</i>	-0.061	0.087	0.098**	0.044
<i>t</i>	0.003	0.002	0.006***	0.002
<i>R</i> ²	0.984		0.982	
<i>N</i>	163		163	

Notes: Significance levels: * = 10%, ** = 5%, *** = 1%.

Table 6: Estimated coefficients of OLS and random effects models with single quality indicators.

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