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Vertical integration in the health system: a Stochastic Frontier Analysis of Local Health Units in the Portuguese NHS

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Abstract: The Local Health Unit (ULS) model is operating in Portugal since 1999 and is being generalized. Hospital care is the subject of much controversy, particularly in emergency services. We developed a study to understand if this new model has been more efficient than the standard model regarding hospital care. We performed a stochastic frontier analysis with data from 4 years, showing that the fact of being an ULS has not been significant for the efficiency of health units and proving that if quantity outputs are used, efficiency scores can be obtained at the expense of quality.

Keywords: Public Policy, Vertical Integration, Local Health Unit, National Health Service

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INTRODUCTION

Every nation needs a robust healthcare system, and Portugal is no exception. Traditionally, health care provision has been based on the separation between Primary Health Care (PHC) and Hospital Health Care (HHC). However, some experiences of vertical integration have been carried out in Portugal with the creation of the Local Health Units (ULS), which vertically integrates both PHC and HHC within a given region. This vertical integration is done from an administrative and management point of view and does not imply the creation of new physical health units.

To increase the effectiveness and efficiency of the healthcare system, considerable structural and organisational reforms are being made in Portugal and the creation of ULS in some regions is one of them. Also, Portugal has problems concerning hospital care, the chaos in the emergency services is widely known and is mediatic (Nunes and Ferreira, 2019). This chaos is due to problems such as a lack of articulation between PHC and HHC (that ULS seek to address), resulting in false emergencies.

With the recent announcements of the expansion of the ULS model to further regions, it is necessary to understand how the existing ULS has worked to anticipate the effect the new ones will have. Consequently, it is essential to study whether the ULS model is more efficient than the standard model concerning hospital care. Our findings will offer helpful information to enhance Portugal's healthcare system.

In conclusion, conducting a research project to assess the efficiency of ULS hospital care versus organically independent hospitals in Portugal is crucial. The study results will provide valuable information about the healthcare sector in Portugal. This information can be used to make

decisions that may be reflected in improving the Portuguese population's overall health and well-being.

THE CONTEXT OF THE ULS IN THE PORTUGUESE HEALTH SYSTEM

In Portugal, the NHS is essential to the population's healthcare. In a population that mostly does not have the financial conditions to afford private health care regularly, it is of utmost importance to have a system financed by the whole population that allows everyone access to the necessary health care. The Portuguese health-care system includes both public and private provision of health care. The financing of the Health System in Portugal occurs via taxes mainly to finance National Health Service (SNS) and via insurance, sub-systems, and direct payments from families mainly to finance private health services provision. This financing is used for activities financed by the SNS itself in public structures such as health centers and hospitals but also in private structures such as pharmacies, agreements for analyses and exams (Barros, P. P., et al. , 2011). Private healthcare is more expensive and usually provides faster access to specialized care. In this project we will focus on the National Health Service.

With the National Health Service, all citizens of Portugal have access to the publicly funded and administered health system, which offers universal coverage. Three tiers comprise the healthcare system: primary care, hospital, and long-term care. Primary care centers which offer essential medical services, preventative care, and health promotion initiatives, provide primary care. Public hospitals, can be broken down into three groups: central hospitals, district hospitals, and local hospitals, providing hospital care. Several public and commercial organizations offer long-term care, such as nursing homes, home care agencies, and hospices. In addition, there is the ULS model, which is based on integrating PHC and hospital care in a single entity (Decreto-

Lei no. 124/2011 de 29 December 2011). This project will explore ULS in detail and understand whether the ULS model is more efficient in the provision of hospital care.

We can see how the NHS is organized in figure C.1.

According to Entidade Reguladora da Saúde (2011), ULS are a "single entity responsible for the health status of a given population, aiming to ensure an integrated provision of health care, with a high degree of efficiency, quality and user satisfaction, through the management of the various levels of care provision (namely, PHC, hospital care and continued care) and of the network coordination of all the elements that are an integral part of it," this suggests a level of integration that will allow easier access to the necessary care and a better articulation between health care services.

With the ULS model there is a vertical integration which allows a greater articulation. The creation of vertically integrated organisations is aimed not only at improving the quality of service, but also at increasing efficiency and user satisfaction (Evans, Baker, Berta, and Barnsley, 2013). The first ULS to be created was in Matosinhos in 1999 with the aim of providing more integrated and efficient care. Since then, several new ULS have been created, covering different regions of Portugal. At the moment, there are 8 ULS in Portugal. These are ULS de Matosinhos, ULS Nordeste, ULS Alto Minho, ULS Guarda, ULS Castelo Branco, ULS Norte Alentejano, ULS Literal Alentejano, and ULS Baixo Alentejo. In figure C.2 we can see where the ULS are currently operating in Portugal.

This model currently covers 1,176,266 inhabitants. With the announcement of the opening of 19 new ULS[1], it is estimated that around 50% of the Portuguese population will be covered, an increase of around 40% compared to the current situation.

The ULS are responsible for ensuring that patients receive the proper attention and care at the proper time and location. To do this, the ULS model has put in place a variety of initiatives to enhance the integration and coordination of care across various levels of the health system. They include establishing clinical guidelines and practices, creating electronic health records, and promoting interdisciplinary care teams.

LITERATURE REVIEW

Vertical Integration

Because of the way ULS is organized, we can expect this greater efficiency because ULS reflects a greater concern to ensure interconnection between health care which is easier given the more centralized management. However, vertical integration also has disadvantages, such as the potential for conflicts of interest or administrative barriers (Ackerman and Kenneth, 2019).

In 2013, Evans et al. (2013) stated that integration assessments have moved from an organisational perspective to an emerging interest in patient-centered measures. The authors also mention that systems built around PHC perform superior to systems built around hospitals.

[1] "SNS vai ter mais sete novas Unidades Locais de Saúde". DN. https://www.dn.pt/sociedade/sns-vai-ter-mais-sete-novas-unidades-locais-de-saude-16234693.html.

Ramsay et al. (2009), analysing the impact of vertical integration on health care, such as organizational structures, how services are provided, clinical outcomes, and patient experience, inferred that this type of integration could benefit from establishing partnerships with local services. However, they highlight that the evidence concerning patient experience, clinical outcomes, and costs remains weak.

In the same year, Lionis et al. (2009) sought to study the current state of primary healthcare in Greece and how well-integrated healthcare services and concluded that besides the fact that the integration of PHC in Greece is still fragile, the interaction and integration between healthcare providers and social care is necessary because it allows better use of healthcare and allocation of resources. They contribute to the efficiency and cost-effectiveness of health institutions. The authors highlight the need for a more coordinated approach to healthcare delivery in Greece, focusing on integrated primary healthcare. They also point out that an integrated primary healthcare model can improve healthcare outcomes, facilitate access to care and reduce long-term costs.

In Florida, K.-H. Lee, et al. (2009) published an analysis of the technical efficiency of several hospitals, showing that economies of scale of non-profit integrated hospitals improved the technical efficiency. It was further shown that there are more negotiating advantages vis-à-vis external partners, significant associations between structural clinical integration and average total burden per admission, between average total burden per admission and surgical complication, and between surgical complication and hospital death. However, it concluded that hospitals with highly integrated structures have not shown any immediate financial benefit. Structural clinical integration has only an indirect effect on patient care outcomes. Coddington, et al. (2005) highlights good coordination between different health services, better

communication between providers and provider-patient reaching to avoid possible medical errors and increase the quality of care.

Vertical integration prioritizes focusing on the user, concentrating on the specificities of the users' diseases and not so much on the providers' needs. It also adds that institutions begin to focus on the general well-being of the population rather than on disease treatment, adopting a more preventive policy (Byrne and Ashton 1999).

Regarding the research done on the vertical integration of the Portuguese NHS, Matos (2013) assessed the impact of the ULS and the ACES on the articulation between PHC and secondary care using the ULS of Castelo Branco and the ACES Cova da Beira. The study aimed to analyse the impact of Local Health Units and Health Centre Clusters on the articulation process between primary health care and hospitals. This study was carried out through a questionnaire with open and closed questions. According to this study, doctors at the ULS under analysis had less contact with patients than doctors from ACES. The percentage of feedback information was also higher in ACES Cova da Beira. This study also studied refusals, but the ULS showed no significant disadvantages or superiority. The study concludes that the effectiveness of ULS is doubtful regarding the articulation between primary health care and hospital health care.

In conclusion, most authors state that vertical integration is positive because it allows for easier access to health care, lower costs in the long term, and a greater focus on prevention. However, the studies underline the importance of some conditions, such as developing partnerships with local services, for the model to succeed.

MEASURING EFFICIENCY IN HEALTH CARE

Econometric methods are required to evaluate the efficiency. These methods can be parametric or non-parametric. Parametric methods admit a functional relationship between inputs and outputs and allow error measurement. To use these methods, it is also necessary to know the associated production function (Marques and Silva, 2006). Non-parametric methods differ in the sense that they do not admit any functional relationship between inputs and outputs. Thus, the specification error is minimal (Mello, et al. 2005). The authors also highlight the method's advantages, such as the possibility of identifying efficient DMUs (*Decision Maker Units*) with similar combinations of inputs and outputs for each inefficient DMU and the ease of working with multiple inputs and outputs. SFA (*Stochastic Frontier Analysis*) is the most widely used parametric method, while among non-parametric methods, DEA (*Data Envelopment Analysis*) is the most popular (Kooreman, 1994).

These are so-called frontier methods. Unlike OLS (*Ordinary Least Squares*), which is an average adjustment method, DEA and SFA are frontier methods that have several advantages over the average adjustment method. Jacobs (2001) concludes that each method has its own set of strengths and weaknesses, as well as the potential to measure different efficiency aspects. Differences in efficiency scores between methods could be due to random "noise" or data deficiencies.

K Lee and Wan (2002) demonstrated in 2002 that hospitals with clinically integrated structures could use resources more efficiently and provide better customer service. They also concluded that structural clinical integration is reflected in the cost-effectiveness of the healthcare production process. The authors used DEA in 2003 to study the relationship between integrated information systems and the efficiency of 349 urban hospitals between 1997 and 1998 K. Lee

and Wan (2003), and they concluded that hospital efficiency increased between 1997 and 1998 and that integrated information systems improved the technical efficiency of these health units. Hospitals implementing a highly integrated information system strategy did not see immediate benefit. However, hospital technical efficiency improved the following year significantly.

In 2009, Amado and Santos (2009) evaluated the performance of health centers in Portugal, compared geographical equity in access to Primary Health Care, and measured technical efficiency and service quality by district using data from 2004 and 2005. They concluded that district health authorities differ significantly in equity of service access, technical efficiency, and service quality. They also suggest that better resource utilization could result in more and better services.

Still in 2009 and in Portugal, Simões and Marques (2009) assessed the performance of Portuguese hospitals using DEA and found that although there may be a high consumption of inputs, this does not always translate into an increase in outputs. The consumption of many inputs is not always reflected in high production levels or a higher proportion of outputs due to the influence of congestion on efficiency. They also saw that in 2005 there were 68 large Portuguese hospitals with significant levels of inefficiency, and more than half of them were congested.

In 2015 Gomes (2015), with data between 2003 and 2011, studied the evolution of hospital efficiency based on 16 health institutions. He concluded that between 2010 and 2011, there was a rationalisation of resources, causing a decrease in costs. It also concluded that Santa Maria Maior Hospital, the Tâmega e Sousa Hospital, and the Coimbra IPO are the most efficient institutions analysed. 2004 is also indicated as the year with the best average efficiency result.

The efficiency and success of this vertically integrated model depends on many factors related to the model and conditions outside the model. Therefore, there is no consensus on its efficiency. It is, therefore, essential to understanding the efficiency this model had in Portugal to understand if it should be generalised in our country.

DATA AND METHODOLOGY

Research Questions

The integration of health services happens because governments aim for better medical assistance and health service to the population. In Portugal, there is wide discussion about hospital care and many problems in hospital emergencies. Considering the announcement of new ULS, it is crucial to study if this model performs better and is the one that should be generalized in our country. Thus, this study becomes essential. Its relevance is even more evident as very few recent studies compare the efficiency of ULS with the "standard" model.

We will then understand if the ULS model is more efficient than standard model concerning hospital care and, with this, understand if the vertically integrated model should be generalised in our country.

Methodological Design

Efficiency will be assessed based on Stochastic Frontier Analysis methods. This will allow us to know which units are more and less efficient, draw an efficiency frontier, and determine efficiency scores.

Our output variables correspond to the total number of emergencies, number of surgeries and number of outpatient visits. These measures are typically used to measure hospital output. Three

SFA regressions (one for each output variable) were created using random effects. Random effects were selected over fixed effects because being ULS is a characteristic invariant over time. After having the regressions and interpreting their coefficients, we will obtain the technical efficiency scores for each health unit. Thus, we can understand which health units and model (standard or ULS) achieve a better efficiency score. We will also perform some descriptive statistics with efficiency scores to understand if considerable variations exist between the health units of the two models. After obtaining the descriptive statistics of the efficiency scores we can draw our first conclusions.

With the efficiency scores of all health units we will be able to run new regressions. For each output variable we will create a regression with a dummy (being ULS or not) and a regression with the readmissions variable as independent variable. This last regression allows us to understand if there is a trade-off between efficiency and quality (since the readmissions variable is a proxy for quality). If the readmissions variable is significant, it means that a change in quality influences the efficiency score.

Data

To conduct the SFA analysis, we divided the variables into inputs and outputs. This division is made because efficiency is determined by comparing inputs and outputs (Figueiredo, 2010). For example, a health unit with fewer inputs and higher output level is generally considered to be more efficient.

This study focuses on understanding whether Hospital Centres or Local Health Units provide better hospital care. Thus, variables portraying the conditions of hospital care were chosen. We will understand which system offers more efficient hospital care, which has been involved in so much discussion in recent times in Portugal, mainly concerning emergency services which

will naturally be reflected in the general conditions of hospital services. It is important to mention that Primary Health Care also indirectly impacts hospital conditions. In hospital centers with better performance, good primary health care services allow populations not to suffocate hospital units so much.

According to Figueiredo (2010), the most used input variables to measure health efficiency are the number of medical doctors, nurses, and other health professionals, beds, the number of beds available for day hospitals, the total number of employees, total costs, and medication costs. The most used outputs are the number of inpatients adjusted by case mix, the number of admissions, the number of discharges, the number of inpatient days, the number of outpatients, the number of consultations, the number of surgeries, and the number of emergency episodes.

Thus, in this study and considering that we intend to compare the hospital services of the Hospital Centres and Local Health Units, the following variables were used for the years 2019 to 2022, for a panel data analysis (Table with detailed description in the appendix):

Hospital Medical Consultations - This variable corresponds to the number of hospital medical consultations, including first and subsequent consultations.

Surgical interventions in hospital care - This variable corresponds to the number of surgeries performed. These surgeries can be of different types: Scheduled, Ambulatory Scheduled, Conventional Scheduled, and Urgent.

Attendances in Hospital Emergency by Manchester Triage - This variable refers to the total number of attendances per year with any priority wristband according to Manchester Triage.

Number of doctors per institution - Corresponds to the average number of physicians per institution. For the ULS, doctors working in the ACES were subtracted.

Number of nurses per institution - This variable is similar to the previous variable. However, it refers to nurses.

Annual occupancy rate - Corresponds to the ratio between the total number of inpatient days by the total number of days the beds were available during the year. This variable indicates the percentage of time patients occupy beds for one year.

% Readmissions within 30 days - This metric indicates the percentage of patients who were readmitted within 30 days of being discharged from their first hospitalization. It is calculated by dividing the number of users readmitted within 30 days by the number of patients discharged and multiplying by 100. This variable can be seen as representative of the quality and not only the quantity of the service.

Lit - This control variable takes the value of 1 if the health unit is located on the coast and 0 if not.

It is important to note that all these variables are annual, corresponding to the sum of the 12 months in the cases of Hospital Emergency by Manchester Triage, Surgical interventions in hospital care, and Hospital Medical Consultations and to the average of the 12 months in the remaining variables. It should also be highlighted that the number of standard patients per doctor and nurse corresponds only to the hospital part of the ULS and omits the PHC. This adjustment was made because otherwise we would be comparing hospitals (only HHC) with ULSs that have doctors in PHC and HHC, and this is not a fair comparison. Thus, we needed to subtract the number of doctors allocated to the PHC of the ULS from the total number of doctors per ULS. The variable "% Readmissions in 30 days," corresponding to the average of all months of the year is essential because gives us an idea of the quality of care provided. We

will use this variable to understand whether variations in efficiency scores happen due to variations in the quality of service provided.

We also have the variable "Attendances at Hospital Emergency," "Hospital Medical Consultations," and "Surgical Interventions in Hospital Health Care," which are annual and studied during the four years under analysis, in the panel in use.

DESCRIPTIVE STATISTICS

In order to analyse the data correctly and before starting to estimate the equations of our model, a descriptive statistics analysis was performed. In addition to estimating the minimum, maximum, mean, median of each variable (Table A.1 and A.2).

Descriptive statistics were analyzed for the whole sample and the standard and ULS models separately.

From the descriptive statistics analysis, the average number of doctors, nurses, emergencies, and surgeries performed is much higher in the standard model than in the ULS model. Concerning the percentage variables, such as the occupancy and readmission rates, the ULS model has a higher value in terms of readmissions, showing quality problems, but the standard model has an higher level in terms of occupancy. This indicates that, although the standard model has a higher occupancy rate, it ensures higher quality standards, leading to a lower readmission rate. The median is also higher in the standard model for all values except for the value of readmissions which is higher in the ULS model.

RESULTS AND DISCUSSION

After treating the data and having a complete database for the four-year panel analysis with random effects (to capture the effects of being or not being ULS), we obtained the following regressions:

Variables	log(surg) **Model 1**	log(emer) **Model 2**	log(app) **Model 3**
Intercept	8.10 ***	8.03 **	9.84 ***
	(0.36)	(3.02)	(0.25)
Number of doctors per institution	0.20***	0.21	0.18**
	(0.04)	(0.32)	(0.06)
Number of nurses per institution	0.50 ***	0.37	0.58 ***
	(0.07)	(0.64)	(0.07)
Annual occupancy rate	0.69***	0.56	0.29***
	(0.00)	(0.69)	(0.07)
Coast	0.04	1.47**	0.18***
	(0.08)	(0.45)	(0.05)
sigmaSQ	0.03 ***	15.44 ***	0.18 ***
	(0.08)	(4.07)	(0.06)
gamma	0.92***	0.95	0.97***
	(0.02)	(0.02)	(0.01)
No. Observations	139	126	125
mean efficiency	0.66	0.18	0.71

Table 1 – SFA models, one asterisk (*) represents a significance level of $p < 0.05$, two asterisks (**) represent a significance level of $p < 0.01$, and three asterisks (***) represent a significance level of $p < 0.001$. Standard errors in parentheses. All independent variables are logarithmic.

With the dependent variable surgical interventions and regarding the independent variable hospital occupancy, this is a control variable and may have a positive sign because a greater demand for health services leads to high occupancy, increasing the number of surgeries performed. However, we may reach a situation where excessive occupancy may harm the performance of surgeries. Thus, there is some ambiguity.

Regarding the variable referring to the number of doctors, we expect a positive sign since, with more doctors, more professionals will be available to perform surgeries. More doctors also lead to shorter waiting times, and thus, more surgeries can be performed. Regarding nurses, we also expect a positive sign because they play a crucial role in pre and post-operative care, allowing more surgeries.

A positive sign is also expected for the variable that indicates whether the healthcare facility is located on the coast or in the interior of the country since there is a greater quantity and diversity of resources, competition between providers, and the possibility of outsourcing (Menezes, Forjaz, José, & Vieira, 1997).

Our results aligned with what was expected, with all the variables being significant except the coastline variable. After confirming the results, we extracted the efficiency scores of the health units under analysis.

When we analyse the dependent variable "log(emer)", we can conclude that we expect ambiguity in the variables. If, on the one hand, more health professionals increase the capacity of emergency services in health units, making them more attractive (it is convenient to go to a service that can perform all exams in the same space), the population may take advantage and "abuse" this increase in capacity. However, the fact that there are more doctors and nurses also improves external consultations services; with a better external consultation service, fewer emergencies are expected, especially in the ULS model which, as greater articulation in health care is foreseen, even fewer emergencies are expected. The Dummy is also ambiguous in that if, on the one hand, in the interior, there is an aging population that will need emergency services more, it is also true that on the coast, the population has more accessible access to health care. For this dependent variable, only the variable indicating whether the health unit is on the coast or inland proved statistically significant. However, all variables had the expected sign.

Finally, regarding the variable of external appointments, we expect a positive sign for health professionals (doctors and nurses) because a more significant number of health professionals may allow for greater and better quality care, which attracts more patients to outpatient appointments. The occupancy rate is also expected to have a positive sign since, in times of higher occupancy, patients who do not necessarily need hospitalization may be referred to external consultations to relieve the pressure on available beds. Regarding the variable on the coast, it is an ambiguous situation for the same reasons as previously mentioned.

Our results were as expected, and the variable referring to the coastline had a positive and statistically significant value. We extracted the efficiency scores.

After checking the quality of the model results and extracting the efficiency scores we could perform a descriptive statistical analysis of the efficiency scores for our three regressions. To do so, we divided the scores by model (standard and ULS) and obtained the data presented in Table 2.

Output Variables	MEAN	MEDIAN	STANDARD DEVIATION
Surgical Interventions in Hospital Care			
ULS	**0.62**	0.60	0.18
Standard Model	**0.66**	0.64	0.20
Attendances in Hospital Emergency			
ULS	**0.23**	0.04	0.30
Standard Model	**0.24**	0.19	0.22
Hospital Medical Consultations			
ULS	**0.72**	0.71	0.15
Standard Model	**0.76**	0.81	0.17
No. Observations	139	126	125
mean efficiency	0.66	0.18	0.71

Table 2 - Descriptive statistics of the efficiency scores

For our first output variable (Surgical interventions in hospital care), we have a mean of efficiency score of 0.66 vs 0.62 with the Standard Model scoring higher. The median is also higher (0.64 vs 0.60) and the standard deviation is higher for the Standard Model's health units (0.20 vs 0.18), making sense as they are more numerous.

Regarding the second variable (Attendances in Hospital Emergency by Manchester Triage), once again, the mean of the efficiency scores is higher for the standard model health units (0.24 vs 0.23). The median is also much higher (0.19 vs 0.04) showing a large discrepancy in the efficiencies of each ULS for this variable. The standard deviation is now higher for the ULSs (0.30 vs 0.22) due to the large variation already evidenced by the medians.

Finally, the variable of outpatient visits shows a higher mean in the standard model units (0.76 vs. 0.72) as well as a higher median (0.81 vs. 0.71) and a higher standard deviation (0.17 vs 0.15). These results are similar to the results for the variable of surgeries.

In conclusion, there is no evidence with the descriptive statistics that the ULS model was more efficient in Portugal in the years under analysis. In mean and median, it always presented lower efficiency scores. Only the median of attendances in hospital emergency was exception but very large variations within the ULS model were seen for this variable.

After evaluating the descriptive statistics for the efficiency scores and finding no statistical evidence of greater efficiency in the ULS model, we estimated an econometric model that will provide additional details. We used a dummy variable that tells us whether the health unit under study is ULS or not and a proxy variable for quality of care (readmissions). As we can see in Table 3, two models were estimated for each dependent variable. One in which the explanatory variable is the dummy variable and the other in which the explanatory variable is the quality proxy variable. We will understand if the variations in the efficiency scores are due to being a standard or ULS model and whether the quality of service interferes with the efficiency scores, regardless of the system.

Variables	Model 1 **surg**	Model 2 **surg**	Model 3 **emer**	Model 4 **emer**	Model 5 **app**	Model 6 **app**
Intercept	0.67***	0.65**	0.22***	0.14***	0.75***	0.67***
	(0.02)	(0.03)	(0.02)	(0.04)	(0.02)	(0.03)
ULS	**-0.04**		**0.03**		**-0.13****	
	(0.04)		(0.04)		(0.04)	
% Readmissions within 30 days		**0.11*****		**1.05*****		**0.70*****
		(0.01)		(0.14)		(0.10)
p-value	0.33	~0.00	0.62	~0.00	~0.00	~0.00
R-Squared	0.07	0.40	0.02	0.31	0.08	0.29

Table 3 – Relationship between efficiency scores of the output variables, the Dummy variable and the proxy of quality. One asterisk (*) represents a significance level of $p < 0.05$, two asterisks (**) represent a significance level of $p < 0.01$, and three asterisks (***) represent a significance level of $p < 0.001$. Standard errors in parentheses. All independent variables are logarithmic.

Concerning the surgeries variable, the dummy variable is not statistically significant. However, the readmissions variable (proxy of quality) has a high degree of significance and positive sign. This suggests that, to some extent, efficiency gains can occur at the expense of a lower quality of care. More readmissions (lower quality) can generate higher efficiency scores. Health units can perform more surgeries when these are performed with lower quality and lead to higher readmission rates.

Similar conclusions can be drawn regarding the variable referring to the number of consultations in the emergency department. The fact of being or not being ULS was not statistically significant, and the quality proxy variable showed once again that the number of consultations in the emergency department depends on the quality of the service. More readmissions (higher number of emergencies but with less quality) can generate higher efficiency scores.

For the variable of outpatient appointments, we can see that the fact of being a ULS negatively and statistically negatively impacts the efficiency score. Regarding quality, we can draw the same conclusions as previously mentioned.

CONCLUSIONS

The Local Health Units system has been present in Portugal since 1999, with the first ULS to be created being the ULS of Matosinhos. This model, which represents significant changes in the administrative and managerial way in which health units operate, has been extended in Portugal and now there are 8 ULS, and recently, 19 more ULS have been announced, reaching 27 ULS, which will cover 50% of the national territory. The conditions of hospital care in Portugal are the subject of many questions and criticisms, including the chaos in emergency services, which is much discussed in the media. That is why it was imperative to conduct a study to understand whether this model, expected to be generalised in our country, could present greater efficiency concerning hospital care.

The literature inside and outside our borders is not consensual regarding the efficiency of this model. While it is true that the model has the potential to ensure a good interconnection between the different levels of care and to reduce costs, it is also evident that it is difficult to organise and align the various structures internally, as well as being more prone to conflicts of interest.

Given this ambiguity and uncertainty about the efficiency of this method, it was necessary to develop this study with a 4-year database, use a Stochastic Frontier Analysis that determined the efficiency scores of the health units of the standard system and the ULS system, analyze these scores to understand which model achieved better efficiency and estimate other regressions that gave us more information about the significance of being or not ULS and about the efficiency scores of all units.

After the estimated regressions, results suggested that there is no systematic relation between efficiency and the ULS model. In one of the output variables, there was even statistically solid evidence of the dummy being detrimental to the efficiency score. It is also clear that, for both systems, efficiency occurs at the "expense" of quality. The health units that "do more" often readmit more. This could be seen when studying the readmissions variable in isolation from the efficiency scores. There was always an increase in efficiency scores for an increase in readmissions. Thus, we should look at the data carefully and evaluate the quality of service provided in health institutions. Moreover, the descriptive statistical analysis allowed us to conclude that in this case, we are not in the case where these institutions have a higher quality but a lower quantity and, therefore, a lower efficiency score, since our descriptive statistical analysis showed that the percentage of readmission in ULS is, on average, higher than in the standard model despite the lower occupancy rates.

The conclusion that the ULS model has no evidence of being more efficient does not mean that the model is not designed more efficiently than the standard model. However, in Portugal, perhaps due to very different populations who can see their needs better met with a model where decision-making is not so centralised, results have yet to be presented that would allow us to conclude that the ULS model has been more efficient. This may change in the coming years with the model's generalization and health professionals' specialization towards this model.

Although this work is essential to address the lack of empirical data that still exists concerning the effectiveness of the ULS model and to draw attention to the care that should be taken when analysing outputs that reflect quantities, not quality (if we use quantity variables, we will have to combine the analysis of the efficiency scores with other analyses such as descriptive statistics, for example), it is fundamental that further research continues on the efficiency of this model, which will be increasingly present in Portugal. Thus, I leave the following suggestions for future work: study the efficiency of ULS compared to the standard model

concerning Primary Health Care and the efficiency of healthcare units in Portugal using variables assessing the service quality.

REFERENCES

Ackerman, F. Kenneth. “The Movement toward Vertically Integrated Regional Health Systems.” Health Care Management Review 17, no. 3 (1992): 81–88.

http://www.jstor.org/stable/44950513.

Allen, Robert, Antreas Athanassopoulos, Robert G. Dyson, and Emmanuel Thanassoulis. "Weights restrictions and value judgements in data envelopment analysis: evolution, development and future directions." Annals of operations research 73, no. 0 (1997): 13-34.

Almeida, Álvaro, and José Pedro Fique. Evaluating hospital efficiency adjusting for quality indicators: An application to Portuguese NHS hospitals. No. 435. Universidade do Porto, Faculdade de Economia do Porto, 2011.

Amado, Carla Alexandra da Encarnação Filipe, and Sérgio Pereira Dos Santos. "Challenges for performance assessment and improvement in primary health care: the case of the Portuguese health centres." Health policy 91, no. 1 (2009): 43-56.

Barros, P. P., Machado, S. R., Simões, J. D. A., & World Health Organization. (2011). Portugal: Health system review.

Byrne, Margaret M., and Adam C. Walmus. "Incentives for vertical integration in healthcare: the effect of reimbursement systems/practitioner response." Journal of Healthcare Management 44, no. 1 (1999): 34.

Coddington, D. C. "Vertical integration: is the bloom off the rose?." In Healthcare Forum Journal, vol. 39, no. 5, pp. 42-46. Healthcare Forum, 1996.

Decreto-Lei n.o 124/2011 de 29 de dezembro, Pub. L. No. 249, Diário da República, 1.a série (2011).

Entidade Reguladora da Saúde. (2011). Análise da Sustentabilidade Financeira do Serviço Nacional da Saúde. From https://www.ers.pt/uploads/writer_file/document/36/Relatorio_Sustentabilidade_do _SNS.pdf

Evans, Jenna M., Ross G. Baker, Whitney Berta, and Barnsley Jan. "The evolution of integrated health care strategies." Annual review of health care management: Revisiting the evolution of health systems organization 15 (2014): 125-161.

Evans, Jenna M., Ross G. Baker, Whitney Berta, and Barnsley Jan. "The evolution of integrated health care strategies." Annual review of health care management: Revisiting the evolution of health systems organization 15 (2014): 125-161.

Expatica. "The healthcare system in Portugal." Expatica Portugal. April 13, 2023. https://www.expatica.com/pt/healthcare/healthcare-basics/healthcare-in-portugal-103703/.

Figueiredo, P. "Avaliação de Desempenho dos Hospitais Portugueses: Aplicação de Métodos Não-Paramétricos." Unpublished doctoral dissertation). Instituto Superior Técnico (2010).

Gomes, Eva Patricia do Vale Pereira. "Eficiência das unidades hospitalares no âmbito dos novos modelos de gestão: aplicação da metodologia Data Envelopment Analysis." Estudos do ISCA 12 (2015).

Iqbal, Munawar, and Philip Molyneux. Thirty years of Islamic banking: History, performance and prospects. Springer, 2016. Jacobs, Rowena. "Alternative methods to examine hospital efficiency: data

envelopment analysis and stochastic frontier analysis." Health care management science 4 (2001): 103-115.

Kooreman, Peter. "Data envelopment analysis and parametric frontier estimation: complementary tools." Journal of Health Economics 13, no. 3 (1994): 345-346.

Lee, Kwangsoo, and Thomas TH Wan. "Effects of hospitals' structural clinical integration on efficiency and patient outcome." Health Services Management Research 15, no. 4 (2002): 234-244.

Lee, Kwangsoo, and Thomas TH Wan. "Information system integration and technical efficiency in urban hospitals." International journal of healthcare technology and management 5, no. 6 (2003): 452-462.

Lee, Kwangsoo, and Thomas TH Wan. "Information system integration and technical efficiency in urban hospitals." International journal of healthcare technology and management 5, no. 6 (2003): 452-462.

MARQUES, Rui C., and Duarte Silva. "Inferência estatística dos estimadores de eficiência obtidos com a técnica fronteira não paramétrica de DEA: uma metodologia de Bootstrap." Investigação Operacional 26, no. 1 (2006): 89-110.

Matos, Inês Lourenço Dias de. "Análise comparativa do impacto das ULS (Unidade Locais de Saúde) e dos ACeS (Agrupamentos de Centros de Saúde) no processo de articulação entre os cuidados de saúde primários e os cuidados de saúde hospitalares." PhD diss., Escola Nacional de Saúde Pública. Universidade Nova de Lisboa, 2013.

Menezes, António Gomes de, Marco Forjaz Rendeiro, and José Cabral Vieira. "Eficiência técnica dos hospitais portugueses 1997-2004: uma análise (regional) com base num modelo de fronteira estocástica." (2006).

Moreira, Sara. "Análise da eficiência dos hospitais-empresa: uma aplicação da data envelopment analysis." Boletim Económico–Banco de Portugal 14, no. 1 (2008): 127-150. Nunes, Alexandre Morais, and Diogo Cunha Ferreira. "Reforms in the Portuguese health care sector: challenges and proposals." The International Journal of Health Planning and Management 34, no. 1 (2019): e21-e33.

Oliveira, Rui Carvalho, and José Soeiro Ferreira. Investigação operacional em ação: casos de aplicação. Imprensa da Universidade de Coimbra/Coimbra University Press, 2014.

Ramsay, Angus, Naomi Fulop, and Nigel Edwards. "The evidence base for vertical integration in health care." Journal of Integrated Care 17, no. 2 (2009): 3-12.

Rechel, Bernd. "How to enhance the integration of primary care and public health? Approaches, facilitating factors and policy options." European Observatory on Health Systems and Policies, Policy Brief 10 (2020).

Simões, Pedro, and Rui Cunha Marques. "Performance and congestion analysis of the Portuguese hospital services." Central European Journal of Operations Research 19 (2011): 39-63.

Simões, T. Caos nas urgências: doentes esperam mais de 12 horas para serem atendidos. NiT. De https://www.nit.pt/fit/saude/caos-nas-urgencias-doentes-esperam-mais-de-12-horas-para-serem-atendidos

APPENDICES

Appendix A - Results of the descriptive statistics

Table A.1 - Descriptive Statistics for both models

Variable	Mean	Median	Minimum	Maximum
med	187,87	117,00	4,16	671,41
enf	943,00	726,80	193,00	3289,00
emer	78605,00	8174,00	123,00	655488,00
ocup	0,84	0,81	0,13	2,42
readmi	0.07	0,07	0,00	0,14
surg	185839,00	149572,00	324,00	701921,00
app	1890970,00	1628685,00	407106,00	5878445,00

Table A.2– Descriptive Statistics for standard and ULS model

	ULS				Standard Model			
Variable	Mean	Median	Minimum	Maximum	Mean	Median	Minimum	Maximum
med	47,40	15,46	4,17	184,59	229,00	150,54	36.75	671,00
enf	555,20	471,40	263,60	1055,30	1057,80	788,00	192.9	3289,90
emer	44069,00	3781,00	527,00	312727,00	86664,00	8314,00	124,00	655488,00
ocup	0.76	0,75	0.60	0,92	0,85	0,83	0,13	2,42
readmi	0.07	0.07	0,04	0,10	0,06	0,06	0,00	0,14
surg	88568,00	67195,00	32141,00	205637,00	208559,00	177689,00	324,00	701921,00
app	817384,00	580630,00	407106,00	1880588,00	2093853,00	1726355,00	450986,00	5878445,00

Appendix B – Definition of Variables

Table B.1 - Detailed definition of the variables analysed

Hospital Medical Consultations	This variable corresponds to the number of hospital medical consultations, including first and subsequent consultations. First consultations are outpatient consultations where the user is examined for the first time in a speciality.

	Subsequent consultations are the consultations to check the evolution of patients, which also allow the evaluation to decide on the maintenance or alteration of medication prescriptions.
Surgical interventions in hospital care	This variable corresponds to the number of surgeries performed. These surgeries can be of different types: Scheduled, Ambulatory Scheduled, Conventional Scheduled, and Urgent.
Attendances in Hospital Emergency	This variable refers to the total number of attendances per year with any priority wristband according to Manchester Triage.
Number of doctors per institution	Corresponds to the number of doctors for each institution. The value presented is the average of the 12 months of each year under analysis. We expect a positive sign for this variable in the regressions with the outputs "Hospital Medical Consultations", "Surgical interventions in hospital care" and "Attendances in Hospital Emergency by Manchester Triage" and a negative sign for the output "% Readmissions within 30 days" as the increase in the number of

	doctors will have a positive impact on the number of outpatient consultations, surgeries, and the ability of hospitals to attend to emergencies. It corresponds to a better quality of service so that fewer readmissions are expected.
Number of nurses per institution	This variable is similar to the previous variable. However, it refers to nurses. We expect the same signs.
Annual occupancy rate	Corresponds to the ratio between the total number of inpatient days by the total number of days the beds were available during the year. This variable indicates the percentage of time patients occupy beds for one year. The higher this rate is, the more difficulties health facilities may suffer. There is ambiguity in the regressions where **"Hospital Medical Consultations"** and **"Surgical interventions in hospital care"** are the dependent variables since the relationship between hospital occupancy and outpatient consultations and the number of surgeries is unclear. Finally, we expect a positive sign for the variable **"%**

	Readmissions within 30 days" because, with higher hospital occupation, there will be a worse quality of service and, thus, a greater tendency to have readmissions
% Readmissions within 30 days	This metric indicates the percentage of patients who were readmitted within 30 days of being discharged from their first hospitalization. It is calculated by dividing the number of users readmitted within 30 days by the number of patients discharged and multiplying by 100. This variable can be seen as representative of the quality and not only the quantity of the service provided since readmissions will be lower in higher-quality services. On the other hand, with a reduced quality service, there will be many readmissions due to health issues needing to be correctly solved.
Coast	This control variable takes the value of 1 if the health unit is located on the coast and 0 otherwise.

Appendix C – Portuguese NHS

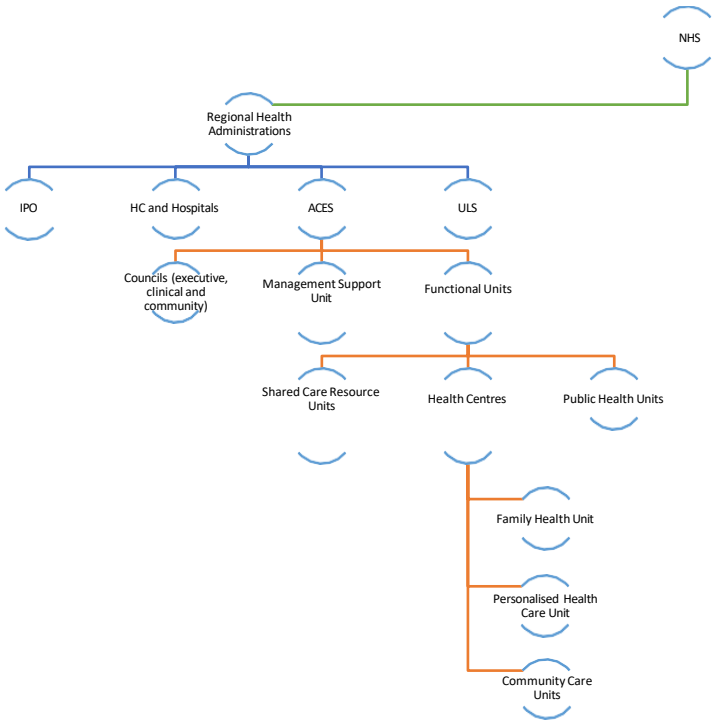

Figure C.1 - Structure of the portuguese NHS (Decreto-Lei n.o 28/2008, de 22 de fevereiro)

Figure C.2 - ULS distribution in Portugal (Entidade Reguladora da Saúde, 2015)