Hospital differences in rates of cesarean deliveries in the Sardinian region: An observational study

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ABSTRACT

BACKGROUND: The rates of cesarean deliveries have been increasing steadily in several European countries in recent decades, with Italy having the second-highest rate (38% in 2010), causing concern and debate about the appropriateness of many interventions. Moreover, some recent studies suggest that rates of common obstetric interventions are not homogeneous across hospitals, maybe not only because of patient case mix but also possibly because of different hospital practices and cultures. Thus, it is important to investigate whether the variation in rates of cesarean sections can be traced back to patient characteristics or whether it depends upon context variables at the hospital level.
METHODS: Using official hospital abstracts on deliveries that occurred in Sardinia over a two-year period, we implement multilevel logistic regression models in order to assess whether the observed differences in cesarean rates across hospitals can be justified by case-mix differences across hospitals.
RESULTS: The between-hospital variation in rates of cesarean delivery is estimated to be 0.388 in the model with only the intercept and 0.382 in the model controlling for the mother's clinical and sociodemographic characteristics.
CONCLUSIONS: The results show that taking into account the individual characteristics of delivered mothers is not enough to justify the observed variation across hospital rates, suggesting the important role of unobserved variables at the hospital level in determining cesarean section rates.

Key words: hospital differences, cesarean deliveries, multilevel models.

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INTRODUCTION

Recent studies suggest that the rates of medical interventions across hospitals are not homogenous, prompting an increasingly debated issue in the medical and public health literature concerning the appropriateness of many of these interventions. This statement is especially true when we focus our attention on a number of common obstetric treatments such as inducing labour and episiotomy. A study on a sample of approximately 18000 cases in Aberdeen found that one-quarter of the variation in rates of induction of labor remained unexplained after controlling for case-mix factors [1]. Similarly, [2, 3] for episiotomy rates, after controlling for socioeconomic factors and individual clinical factors, a large proportion of the total variability remained unexplained.

According to above, the debate around cesarean sections becomes even more significant [4, 5, 6], likely because of its high social cost and its highly frequent application in medical practice. In fact, the widespread use of cesarean deliveries has important policy implications [5]: cesarean sections are much more expensive than vaginal deliveries and the higher risk of adverse outcomes and associated complications represent additional social costs for the health system and society. Indeed, cesarean deliveries have been steadily increasing in several Western countries during recent decades, with the most documented cases in the United States [5] and the United Kingdom [6]. European official reports [7] show higher rates of cesarean sections for countries in the Mediterranean (e.g., Cyprus at 53%, Italy at 38%) compared to most northern countries, which have rates below 20%. Various explanations have been offered for this increase, including changes in mothers' preferences and the role of obstetric providers [7]. However, as for other procedures, the average rate may obscure rather different intervention patterns across hospitals. These differences may be of a logistic nature; for example, the concentration of mothers with similar characteristics in the same hospital, but may also be due to local hospital practices. The latter leads to an unreasonable situation in which individuals with the same personal preferences and clinical conditions have different likelihoods of accessing cesarean delivery.

The aim of this paper was to assess whether the variation of cesarean section rates across hospitals observed in Italian data still existed after controlling for observable clinical and risk factors. Were this to be the case, we would conclude that two individuals with the same clinical indications but delivering in different hospitals would have different probabilities for undergoing a cesarean section. This would in turn prompt the potential for a reduction of unnecessary interventions.

Following this brief introduction, the remainder of the paper is organized as follows: section 2 provides an overview of the data used and of the empirical strategy employed in the analysis, while section 3 provides the main empirical results. Following on, section 4 concludes the paper by exploring the limits and implications of our findings.

METHODS

We considered a data set containing information pertaining to deliveries that occurred in 20 hospitals in the Italian region of Sardinia over a two-year period, from 2010 to 2011. The data set consisted of the information contained in the "Certificato di Assistenza al Parto" (CeDAP), an official abstract designed for capturing not only the clinical features of mothers and infants, but also the main social and demographic characteristics of the family unit. Of the 23925 hospitalized pregnancies during the time window, we selected only observations from expectant mothers aged between 15 and 44 and with the following features: term or mild preterm stage (33 or more weeks of gestational age), singleton (one offspring) and the child to be delivered classified as vertex (in the head down position). Moreover, we further restricted the data to nulliparous women (i.e., at first birth), reaching a final sample of 14663 cases. The sample chosen can briefly be described as the "low risk of cesarean section" subset of the population, while the decision to use this subset can be justified by noting that it should be the target of a hypothetical effort aimed at reducing the overall total rate of cesarean sections.

In order to explain differences among cesarean deliveries, we relied on a set of case-mix factors that can be classified as medical or social. For the former, we used medical factors from the literature usually considered to be an indication for cesarean sections, for example, infant weight, gestational age and induction of labor [2]. For the latter class, we used sociodemographic variables, i.e., maternal age and the mother's educational background, the impact of which is considered crucial in the literature.

It is possible that not all the factors that contribute to the decision of performing a cesarean section had been observed in this study. In particular, we are concerned about unobserved variables that do not vary at the hospital level, such as obstetric practice, the preferences of the physicians working together in a same hospital and guidelines promoting or restricting the liberal use of cesarean sections. Therefore, following [4] and in order to assess the importance of these variables, we modelled the likelihood of an intervention using a two-level logistic model with the individual predictors at the lowest level of the hierarchy, and a random intercept at the hospital level, taking into account all unobserved predictors at the hospital level.

Using the latent response formulation, the model can be written as follows:

$$y_{ij}^* = \beta_0 + \beta_1 x_{1ij} + \ldots + \beta_k x_{kij} + \varsigma_j + \varepsilon_{ij}$$
(1)

where y_{ij}^* is the propensity of observing $y_{ij} = 1$; this happens if a cesarean section has been performed in patient i in hospital j; $x_{1ij}, \ldots, x_{kij}$ are the k clinical and sociodemographic predictors for individual i delivered in hospital j, whereas ς_j is the random intercept at the hospital level where individual i has been admitted and it is normally distributed with zero mean. The fixed-effect part of the model allowed us to consider clinical indications for predicting cesarean sections within each hospital, while the random intercept was meant for underlining systematic differences between hospitals. Finally, ε_{ij} is the remainder error term and is distributed as a logistic. Model 1 belongs to the category of mixed-effect models (see [8] for a computationally-oriented presentation) and can be estimated using several statistical packages. In our case, we chose the R software for statistical computing (package lme4), which performs all calculations using the simulated maximum likelihood [9]. Given the large sample size, we considered significant, at various levels, results with a pvalue lower than 0.05. The full significance level set has been displayed under each table.

The variables chosen as predictors at the individual level were the same as those used in [4], with the exception of maternal age, which was categorized as in [6]; variables were listed as follows: maternal age (grouped in five categories: 15-19, 20-24, 25-29, 30-34 and 35-44 years); mother's educational background (ordered into four separate categories: less than high school, high school, graduate or postgraduate and a residual category collecting missing values); infant weight (measured in grams and grouped into the following ordered categories: <2500; 2500-4000; ≥4000); gestational age was categorized into three classes: preterm births (32-36 weeks), normal-term births (37-41 weeks) and late-term births (at least 42 weeks). This differed slightly from [2], because it also included mild preterm babies. Finally, we included in the model two dummy variables, the first for indicating whether a mother has undergone an induced labor and the second for the presence of a pregnancy-related pathology. The latter variable was set to 1 if at least one of the following conditions occurred during pregnancy: diabetes mellitus, eclampsia, hypertension or placenta previa. Descriptive statistics for the above variables are shown in Table 1.

RESULTS

Table 2 indicates the counts and proportions of cesarean section according to hospital. Observations of interest are clustered among 20 hospitals: frequencis of cesarean sections vary across hospitals from a minimum of 0.11 to a maximum of 0.64.

We modelled the likelihood of cesarean section using equation 1 in order to indirectly drive back the observed rates of interventions to both observed individual covariates and unobserved hospital-level covariates.

The parameter estimates of model 1 are shown in Table 3. As expected, maternal age was significant and showed a monotone relationship with the likelihood of cesarean section: the older the mother, the higher the likelihood of an intervention. The mother's educational background was significant at the 5% level, with mothers with a high school diploma more likely to be delivered for a cesarean intervention. Infant weight was also a good predictor for determining cesarean rate: the heavier the child, the more likely the potential for a cesarean section to be performed. Finally, gestational age and the presence of pathologies during pregnancy were good predictors for the likelihood of a cesarean delivery. More importantly and

TABLE 1

DESCRIPTIVE STATISTICS FOR MOTHER'S CHARACTERISTICS

PREDICTORS	$y_{ij}=1$	$y_{ij}=0$	% WITH $y_{ij}=1$	% WITH $y_{ij}=0$
Labor induction	2218	1161	0.656	0.343
Pathology during pregnancy	435	568	0.433	0.566
MATERNAL AGE (YEARS)				
15–19	301	76	0.798	0.201
20–24	846	321	0.724	0.275
25–29	1919	808	0.703	0.296
30–34	3682	1929	0.656	0.343
35–44	2606	2175	0.545	0.454
MOTHER'S EDUCATION				
Less than high school	3376	1847	0.646	0.353
High school	4105	2351	0.635	0.364
Graduate or postgraduate	1128	691	0.620	0.379
Missing	745	420	0.639	0.360
INFANT WEIGHT (GRAMS)				
<2500	415	559	0.426	0.573
2500–4000	8686	4502	0.658	0.341
≥4000	253	248	0.504	0.495
GESTATIONAL AGE				
Preterm (<37 weeks)	401	589	0.405	0.594
Normal term (37–41 weeks)	8895	4684	0.655	0.344
Late term (≥42 weeks)	58	36	0.617	0.382

despite all individual predictors showing the indications and magnitudes consistent with the findings of epidemiological studies in the recent literature [4-6], these variables were not sufficient to fully account for the variation rates at the hospital level, as evidenced by the value of the estimated group standard deviation.

In Table 4, the model with the random intercept only (M0) is compared with the full model, including both the random intercept and all covariates (M1). A likelihood ratio test was also implemented in order to compare both M0 and M1 with the respective models without a random intercept. The results of the test rejected the hypothesis that models without a random intercept performed better at 0.001 level.

The first model had an estimated standard deviation of the random intercept ς_j of about 0.39, which remained largely the same after including all the predictors. Having included the most important predictors at the individual level, we may thus infer a role for unobserved variables, possibly at the hospital level, in determining the likelihood for performing a cesarean section, at least for the data observed in this study. In the next section, we discuss some implications of these results.

DISCUSSION

Variation in rates of medical interventions is a relevant issue in the medical literature because it may be realized even if unnecessary. In the case of cesarean sections, the concern about unnecessary interventions is amplified by its economic cost and by the constant reports of high rates of interventions in many countries, including Italy.

In this work, we reported a consistent variation in rates of cesarean deliveries across hospitals, which remained unexplained after conditioning on medical indications and socioeconomic characteristics of the mothers.

TABLE 2

NUMBER AND PROPORTION OF CESAREAN SECTIONS BY HOSPITAL

HOSPITAL	NO. OF BIRTHS	% OF BIRTHS	NO. OF UNCOMPLICATED BIRTHS	NO. OF CESAREAN SECTIONS	% OF CESAREAN SECTIONS
1	2985	0.124	2495	1138	0.45
2	2778	0.116	1763	607	0.34
3	2642	0.110	1681	535	0.31
4	2445	0.102	1462	623	0.42
5	2361	0.098	1253	410	0.32
6	1902	0.079	1191	425	0.35
7	1671	0.069	976	237	0.24
8	1269	0.053	874	238	0.27
9	1081	0.045	529	190	0.35
10	812	0.033	433	134	0.30
11	762	0.031	403	164	0.40
12	707	0.029	396	117	0.29
13	685	0.028	351	134	0.38
14	511	0.021	266	74	0.27
15	465	0.019	206	98	0.47
16	453	0.018	190	122	0.64
17	203	0.008	103	40	0.38
18	107	0.004	50	9	0.18
19	76	0.003	32	13	0.40
20	10	0.000	9	1	0.11
Total	**23925**	**1.000**	**14663**	**5309**	**1.000**

The study extends previous results from United Kingdom and United States to the Italian region of Sardinia, obtaining surprising similarities with the findings of a recent analysis based on US hospitals [4]. The results reveal that the set of predictors used in the literature is not adequate for forecasting cesarean rates. This is partly due to some limitations of the current Italian abstract used for birth events since it does not specify precisely which is the morbidity condition related to the field "pathological pregnancy" but only provides a dummy variable for a whole set of different cases. However it is still possible that even a more complete abstract form does not suffice to explain the observed differences in cesarean section rates [4] as many crucial predictors are inherently difficult to observe because they can be identified with the local medical habits determining a cesarean intervention in a given hospital. In fact, the main result of this study is that women characterized by similar clinical and socioeconomic profiles may experience different cesarean rates simply because they deliver in different hospitals. This lack of homogeneity in treatment assignment is a critical point for public policy in the health sector and suggests the opportunity of further studies on the determinants of cesarean rates that include predictors at the hospital level.

Obviously (and despite that the observed average rate of 36.2% of cesarean sections is similar to the national one), it is not possible to extend automatically the conclusions of this study to the Italian population because of the relatively small contribution of Sardinian births to the country total. Moreover, our findings rest on the peculiar organization of the Sardinian health sector, where the majority of births is concentrated in hospitals directly managed by the regional administration and in University hospitals and the role of private and licensed providers of obstetric services is quite limited (1 792 births over 23 925, equal to 12%), at least in comparison with other Italian regions.

TABLE 3

ESTIMATED COEFFICIENTS OF A MULTILEVEL MODEL FOR PREDICTING THE PROBABILITY OF A CESAREAN SECTION

PREDICTORS	ESTIMATED COEFFICIENTS	SE	P VALUE	SIG.
Intercept	-2.303	0.179	<0.001	***
Labor induction	-0.042	0.044	0.339	
Pathology during pregnancy	0.684	0.071	<0.001	***
MATERNAL AGE (YEARS)				
15–19	Ref			
20–24	0.452	0.147	0.002	**
25–29	0.567	0.137	<0.001	***
30–34	0.785	0.134	<0.001	***
35–44	1.247	0.134	<0.001	***
MOTHER'S EDUCATION				
Less than high school	Ref			
High school	0.107	0.046	0.021	*
Graduate or postgraduate	-0.008	0.062	0.894	
Missing	0.011	0.081	0.889	
INFANT WEIGHT (GRAMS)				
<2500	0.510	0.079	<0.001	***
2500–4000	Ref			
≥4000	0.752	0.093	<0.001	***
GESTATIONAL AGE				
Preterm (<37 weeks)	0.600	0.079	<0.001	***
Normal term (37–41 weeks)	Ref			
Late term (≥42 weeks)	0.175	0.219	0.422	
GROUP STANDARD DEVIATION	0.382			

***p < 0.001; **0.001< p <0.01; * 0.01 < p <0.05

TABLE 4

ESTIMATED STANDARD DEVIATION OF THE RANDOM INTERCEPT FOR THE MODEL WITH ONLY RANDOM INTERCEPT (M0) AND FOR THE MODEL WITH COVARIATES (M1)

	M0: ONLY RANDOM INTERCEPT	M1: M0+ CLINICAL AND SOCIODEMOGRAPHIC VARIABLE
Group standard deviation estimation	0.388	0.382
LR test (Ho: Model without ς_j performs better)	***	***

***p < 0.001; **0.001< p <0.01; * 0.01 < p <0.05

CONCLUSION

In any case, this paper represents a further step to the literature applied to cesarean rates, highlighting the importance of better aligning hospital practice in order to reduce social costs and increase the efficiency of the health system.

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