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A self-reported work sampling to assess the Emergency Department's costs

Paolo Cremonesi, SCMCAU E.O. Galliera, Italy
Enrico di Bella, University of Genoa, Italy
Marcello Montefiori, University of Genoa Italy
Luca Persico, University of Genoa, Italy

Abstract

Emergency Department (ED) activity involves a consistent absorption of resources varying from medical staff to laundry services. Moving from the consideration that staff cost is the most relevant item among those reported in the ED balance sheet, we have conducted a statistical survey in one of the most relevant Italian ED with the goal of providing an accurate estimation of the cost incurred by ED according to the patient severity type (measured by the triage coding).The main contribution of the present paper consists in suggesting a new methodological approach to the ED cost analysis. Personnel and other costs are jointly considered in order to define, by the use of two different cost modeling scenarios, a per patient standard cost which takes into account the patient type and outcome.

Keywords: *emergency department, self-reporting work sampling, standard cost*

JEL Codes: *H51, I18, C51*

1. Introduction

The Emergency Department (ED) is one of the most demanding among all the hospital's departments both in terms of economic resources consumption and programming. The literature suggests they are responsible for a large share of the overall hospital's admissions [Williams (1996), Cremonesi et al.(2010), Sartini et al. (2007)] and examinations (such as x-rays) [Williams (1996)]. In the current scenario of reduced resources devoted to health care providers, hospitals are forced to closely scrutinize the information referring to their EDs with particular reference to their costs. EDs must, along with the other departments and the whole health care system, pursue the cost containment goal in such a way that the overall quality and the level of services provided would not decrease. Therefore it turns to be crucial to define indices and criteria to evaluate the emergency units both in terms of efficiency and quality. To this extent, the ED activity has to be monitored and optimized in order to provide the best outcome in terms of quality of care subject to a budget constraint. Optimization of patient flow and bottleneck elimination is a viable way at policy maker disposal to decrease operational cost and boost the quality of care [Tyrance et al. (1996)].

Strictly correlated with quality is the problem of overcrowding: delays in the ED may have particularly dramatic outcomes for patients. ED congestion is the cause of a two-sided problem: on the one hand congestion affects the quality of care, on the other hand it affects, because of inefficiency in the production process, the cost control. Tyrance et al. (1996) analyse the way non-urgent patients affect the high ED costs. Their paper reaches the conclusion that non-urgent ED accesses are not responsible of high cost in the US EDs. The same conclusion is reached by Williams et al. (1996) who estimate the average and the marginal cost both for urgent and non-urgent patients and show that the money saving that could be gained (transferring non-urgent patients to other “less expensive” structure) is negligible. Bamezai et al. (2005) reach a different conclusion and they conclude that the ED activity should be re-organized because of the high marginal cost for non-urgent ED visits.

With reference to the quality of the services provided when overcrowding is detectable, Hoot et al. (2006) study the ED overcrowding in terms of the national health service’s quality, and Hoot et al. (2007) define four different criteria to measure and forecast the ED overcrowding. Kulstad et al. (2010) find a positive correlation between overcrowding and therapeutic errors using the

Edwin score. Also Pines and Yealy (2009) consider ED overcrowding responsible for deficiencies in terms both of quality and effectiveness of the treatments provided. To conclude the survey it deserves to quote the study of Rossile et al. (2008) suggesting that the optimization of the clinical pathway of patients can't be defined disregarding the elderly: an efficient programming of clinical pathway can't be done disregarding the peculiarities of people over 75.

This paper is intended to move in the direction of the analysis of ED cost composition and impact by a investigation based on microdata referring to the health related services provided by a ED belonging to an Italian primary Regional Hospital. The clinical data are matched up with the relevant accounting and economic information concerning the cost faced by the ED aiming at the goal of providing a new approach in order to identify the standard production costs and their variability between the different types of patients.

2. The database

In order to investigate Emergency Department cost structure, data referring to patient logistics have been collected along a whole week[1] and matched up with the relevant accounting and economic information concerning the cost incurred by the ED. By the electronic data processing center (W:OOD)of the ED of *OspedaliGalliera*, we have collected datareferring to 1,045 patients.The information available with reference to each patient concerns: i. *Date and time of arrival* (it refers to triaging time); ii. *Medical attendant* (that is the identification code of the accepting

[1]From Thursday 9th December 2010, 8:00 pm to Thursday 16th December 2010, 8:00 pm.

medical staff); iii) *Triage entrance code*[2] (patient assignment to the classification code based on patient severity, it refers to the following severity scale: 0 = white, 1 = green, 2 = yellow; 3 = red; 4 = black i.e.deceased); iv. Patient's *personal information* (gender, date of birth, residence and nationality); v. *Means of transport*: arrival mode (by his own, ambulance, air ambulance, etc.); vi. *Admission cause* (morbidity, accident at work, traffic collision, violence, domestic accident, dog attack, scholastic injury, self-mutilation, biological accident, etc.); vii. *Arrival typology*(direct arrival, family doctor, specialist, emergency medical service, other hospital ward, etc.); viii. *Date and hour of visit*(that is the time of the first visit corresponding to patient assignment to a physician); ix. *Laboratory and non-laboratory prescription*(a separate dataset containing all the information about patient health treatment, as for instance, number of events, prescription code, date and hour of each event); x. *Event cost table* (it consists on a separate dataset containing,with reference to each prescription, all the relevant information about health treatment costs; xi. *Patient outcome*(ED healthcare process outcome: discharged, hospitalized, transferred to other medical structure, moved to OBI[3] ward, moved to short hospitalization DB[4] ward, abandonment, expelled, deceased in ED, dead on arrival, hospitalization refusing); xii. *Attending Physician* (identification code of the discharging doctor); xiii. *Prognosis* (number of prognosis days); xiv. *Discharging code*(patient re-assignment, when necessary, of a newtriage code, i.e., at the end of the process it may be required to varythe triage code previously

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2 We refer to severity scale used in Italy in order to assess the overall severity of an ED admitted patient's illness based on the patient's unique clinical conditions, their interaction, and the resultant combined risk of morbidity and mortality.

3 OsservazioneBreveIntensiva: hospital ward which admits patients with prognosis lower than 24 hours.

4 DegenzaBreve: hospital ward which admits patients with prognosis greater than 24 hours but lower than 72 hours.

assigned); xv. *Date and hour of discharging*(it refersto the patient report closing time).

3. Methodology and data analysis

The main item in the ED balance sheet is the Medical staff cost whose imputation to each of the four Triage Codes is not automatically possible. A first approximation suggests to split the Medical staff cost proportionally to the time each doctor spends in visiting each patient, which in turn is characterized by a specific triage code. With this task in mind, we asked the Medical staff of the ED of E.O. OspedaliGalliera, a primary general hospital in Genova, to record the actual time that each ED Doctor dedicated to each patient. Some basic statistics for the 1,011 patients visited during this week are given in Table 1. Consistently with the results shown in Cremonesi et al. (2010), red and yellow codes are older than white and green codes whereas the gender composition is quite balanced between males and females.

Table 1 - *Descriptive statistics for the 1,011 patients visited by the ED Medical Personnel during the sample week.*

Triage Code	*Patients*	*Age (mean)*	*Gender (% male)*
W	81	38	36%
G	689	46	50%
Y	219	64	48%
R	22	76	55%
Total	1.011	50	49%

At a deeper analysis level of the data collected, a significant difference in the visiting time emerged, because of a number of reasons. First, red codes require, generally, a longer visiting time, but at the same time there are some red codes (for example people affected by heart attacks) which do not require a long visiting time as the symptoms are easily identifiable and standard procedures are well defined in protocols. The twenty-one doctors cycled during the week and the number of patients they visited was variable according to the turns in which they worked during the week (workdays, week-end), hour of the day (day, night) and specialization (surgery, clinical doctors). It also happened that a few doctors had to visit and assist a few red or yellow codes whereas other doctors visited a lot of white and green codes. Therefore the variable "Medical Doctor" is relevant as each doctor has, for various reasons his own personal distribution of waiting times. Figure 1 gives a outlook through box-plots of all these waiting time distributions per each doctor. Moreover, in the rush of an ED where the life of people is in peril, it happened that some doctors forgot to note the visiting time of each patient so that only for 729 patients (72% of the total) this is available (see Table 2).

Figure 1 - *Box plots representing the visiting time distributions per doctor.*

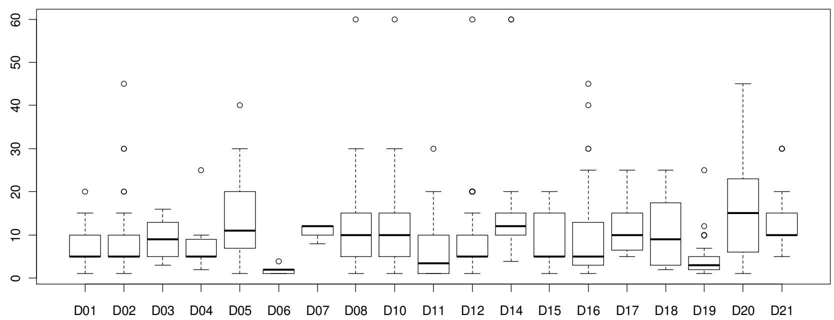

Table 2 - *Visited patients and noted visiting times for each of the 21 doctors.*

Doctor	Visited patients	Noted patients	%
D01	91	77	85%
D02	79	64	81%
D03	29	25	86%
D04	30	14	47%
D05	40	24	60%
D06	51	11	22%
D07	17	3	18%
D08	57	51	89%
D09	27	-	0%
D10	54	44	81%
D11	67	56	84%
D12	96	70	73%
D13	2	-	0%
D14	21	17	81%
D15	14	13	93%
D16	45	36	80%
D17	72	60	83%
D18	14	12	86%
D19	106	64	60%
D20	50	49	98%
D21	49	39	80%
Totals	**1.011**	**729**	**72%**

To face all the aforesaid points, and in particular to neutralize the "Medical Doctor" variable effects, a three steps analysis has been done:

1. all the visiting time distributions of the 18physicians(the procedure adopted herein described excluded the 3 physicians with a number of noted patients less than 10 are excluded) have been

standardized in order to have distributions all having null mean and unitary variance and, *de facto*, neutralizing the difference in mean and dispersion among the different doctors;

2. On the basis of the standardized values, a linear model has been estimated to express the visiting time as a function of clinical and demographic variables (parentheses indicate the coefficient sign):

$$V_T = \underset{(-)}{\beta_0} + \underset{(+)}{\beta_1} D_G + \underset{(+)}{\beta_2} D_Y + \underset{(+)}{\beta_3} D_R + \underset{(+)}{\beta_4} G + \underset{(+)}{\beta_5} A + \underset{(+)}{\beta_6} P_{nl} + \underset{(+)}{\beta_7} P_l + \underset{(-)}{\beta_8} OC + \underset{(-)}{\beta_9} H + \underset{(-)}{\beta_{10}} F \qquad (1)$$

being:

- V_T : the standardized visiting time;
- D_G, D_Y, D_R: the triage color dummies (white triage color confounded with the intercept);
- *G*: Gender dummy (Male = 1; Female = 0);
- *A*: Patient's Age;
- P_{nl}: Number of NolabPrescriptions;
- P_l: Number of Lab Prescriptions;
- *OC*: Overcrowding measured as number of patients that are contextually visited;
- *H*: Hospitalization Dummy (Hospitalized = 1; Not hospitalized = 0)
- *FT*: Fast TrackDummy (Fast Tracked patient = 1; Not Fast Tracked patient = 0)

The estimates of the parameters of model (1) and their significativity are given in Table 3.

On the basis of the econometric model derived, the 319 missing values have been estimated. All the values have been de-standardized using a 5% trimmed mean and 5% trimmed variance in order to cut the 5% of extreme values (highest and lowest)

Table 3 - *Regression coefficients for model (1).*

Coefficients:	Estimate	Std. Error	t value	Pr(>|t|)	
$Intercept$	-0,83068	0,14590	-5,69300	0,00000	***
D_G	0,10037	0,11539	0,87000	0,38472	
D_Y	0,38601	0,14990	2,57500	0,01022	**
D_R	0,41014	0,24302	1,68800	0,09191	*
G	0,02925	0,05957	0,49100	0,62352	
A	0,00300	0,00157	1,91200	0,05622	*
P_{nl}	0,12431	0,01675	7,42000	0,00000	***
P_l	0,04377	0,00583	7,50500	0,00000	***
OC	-0,00476	0,00282	-1,68800	0,09183	*
H	-0,00348	0,09538	-0,03700	0,97087	
FT	-0,38333	0,12320	-3,11200	0,00194	***

Signif. codes: ***<0.01, **<0.05, *<0.1

Residual standard error: 0.7893 on 715 degrees of freedom
Multiple R-squared: 0.3864, Adjusted R-squared: 0.3778
F-statistic: 45.02 on 10 and 715 DF, p-value: < 2.2e-16

The new waiting times for the triage codes are the ones given in Table 4. The Triage color weights have been estimated computing the ratios between the color means and the white triage color mean (Table 4). For instance, white colors weight is 1 (3.12/3.12), green colors is 2.55 (7.95/3.12), yellow colors is 4.67 (14.56/3.12) and red colors is 6.23 (19.43/3.12). In other words it emerges that green codes have an average visiting time that is more than the double of the white codes while yellow and red codes have a visiting time that is more than four and sixtimes respectively the visiting time of white codes.

Table 4: *De-standardized means and Triage Color codes.*

Triage Code	***Patients***	***Minutes (mean)***	***Minutes (SD)***	**Weight**
W	81	3.12	4,60	1,00
G	689	7,95	5,17	2,55
Y	219	14,56	8,25	4,67
R	22	19,43	17,19	6,23
Total	1.011	9,24	7,32	

If the mean visiting times are split into young people (people under 75 years old, with the dummy for Age equal to 0) and elderly (people over 75 with dummy for Age =1), the weights of color codes are given in Table 5. It emerges that, for White and Red codes, the weight of elderly is lower than the weight of younger. On the contrary, for Green and Yellow codes, the weights are higher for elderly.

Table 5: *Weights of colore triage for elderly (AGE = 1) and young (AGE = 0) patients.*

Triage Code	Young	Elderly
W	1.00	0.73
G	2.39	3.37
Y	4.42	4.81
R	7.00	5.63

4. Cost Analysis

The Emergency department faces different costs according to the structure we are observing. The table below provides the percentage composition of different cost type.

Table 6: Cost Composition

	Emergency Dep	Observation	Short Hospitalization
	Fixed Costs Composition		
Medical Doctors	36,78%	12,82%	12,09%
Nurses	22,66%	61,38%	31,94%
Other Personnel	10,56%	0,00%	18,37%
Mortgages and other expenses	5,69%	3,66%	7,27%
Administrative Staff	1,26%		
Cleaning	0,35%	0,00%	4,37%
Fixed Costs Total	**77,30%**	**77,86%**	**74,04%**
	Variable Costs Composition		
Surgical & Medical devices	2,68%	1,84%	2,18%
Drugs	1,78%	1,53%	1,84%
Kitchen & Laundry	0,35%	1,24%	4,41%
Health Services	0,36%		
Variable Costs Total	**5,17%**	**4,61%**	**8,43%**
	Common Costs		
Common Costs	**17,53%**	**17,53%**	**17,53%**
TOTAL	100%	100%	100%

Analysing economic data, it emerges that the cost for physicians, nurses and other personnel counts for the 71,27%, 74,20%, 62,40% of the total costs incurred respectively by the ED, Observation and Short Hospitalization. Therefore information concerning the amount of time workers spend on particular activities is crucial to correctly assess the ED per-patient cost. Is to this extent that we implemented the afore-mentioned week of surveywhere all physicians practicing in the ED were asked to note down the total amount of time actuallydedicated to each patient: consisting of preliminary visit, report reading and discharge procedures[5].

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[5]The ED activity is organized on three shifts (8:00 a.m. – 2:00 p.m. – 8:00 p.m.). At the end of each shifts, all the gathered reports were collected and verified in

%

By this self-reported work-sampling procedure we could add a new variable crucial to our analysis: theactual visiting time and obtain weights of table 4.

However, the first necessary step is the identification of per cost. We get this information by simply dividing the cost as they are provided in the balance sheet[6] taking into account the number of patients:

$$\frac{FC+VC+CC}{n.\,of\;patients}=139.74€=\begin{Bmatrix}107.28\;(fixedcost)\\7.96\;(variablecost)\\24.50\;(commoncost)\end{Bmatrix}$$

Table 7: Patient outcome

Triage Code	***Patients***	**ED**	**OBI**	**DB**
W	81	79	2	0
G	689	649	29	13
Y	219	166	40	17
R	22	19	0	3
Total	1011	913	71	33

Please note that the total number of ED, OBI and DB patients sums to 1017 rather than 1011. The explanation relies on the fact that 6 patients have been hospitalized in DB after the Observation period.

Using Table 7 it is possible to define the patient cost according to his outcome:

	Emergency Department	**Observation**	**Short Hospitalization**
Per patientcost	€ 119,96	€ 105,56	€ 735,02

order to minimize the risk of missing values.

6 To note that cost emergenging from the balance sheet does not take into account the cost for laboratory, non laboratory and x-ray activity.

But costs should be imputed according to the actual resource consumption that is generally strictly correlated with the patient severity. Cremonesi et al. (2010) arbitrarily weight the patients according to the triage code. In fact they observe that time spent to receive the first visit after the triage attribution decreases as the as long as the patient severity (i.e., the triage code) increases. On the other hand the time elapsing between the first visit and the exit time increases with the triage classification. To this extent they assume that a larger time period to exit implies a larger resource consumption by the patient in terms of: i) medical and non-medical staff; ii) clinical tests; iii) drugs; iv) equipment; v) other.

In this work the “Basic Scenario” of Cremonesi et al. (2010) is overcome through the definition of new weights estimated using the data collected in the sample week (cfr table 4). As it clearly emerges from Table 4 the white code patient turns to be a sort of benchmark for the weight associated to other colors. For instance a green code is assumed to have a cost of 1.92 times greater than a white. A yellow code costs 3.12 times the white. In other terms we may think at equivalent patients, where the “equivalence” refers to cost. The hospitalization of a red code patient is equivalent, in terms of resource absorption, to 3.41 white code patients. This new scenario suggests a new cost classification which takes into account the triage classification.

At this stage two hypothesis are possible:

1st HP
$$ {}_{structure}PatientCost_{TriageCode} = \frac{FC + CC}{N.ofPat.} + \frac{VC}{Eq.Pat.} * Weight_{TriageCode} \quad (1) $$

2nd HP
$$ {}_{structure}PatientCost_{TriageCode} = \frac{FC + CC + VC}{Eq.Pat.} * Weight_{TriageCode} \quad (2) $$

By the first hypothesis (1) the new equivalent patients are used to assess only the variable cost component, while the other cost component are computed without weighting patients.The assumption underneath relies on the fact that only variable costs should be affected by the intensity of the clinical assistance whereas fixed costs do not vary.

The second hypothesis (2) moves from the observation that we are searching, from an economic point of view, the actual resource consumption by different types of patients. To this extent all the cost incurred by the ED are shared using the weighted patients criterion.

To implement these hypothesis the computation of equivalent patient according to the outcome is required.

Triage Code	**ED eqpat**	**OBI eqpat**	**DB eqpat**
W	79,00	2,00	0,00
G	1654,95	73,95	33,15
Y	775,22	186,80	79,39
R	118,37	0,00	18,69
Total	2627,54	262,75	131,23

Table 8:Total costs per triage color, structure and hypothesis

	Hypothesis 1			**Hypothesis 2**		
	ED	Obs.	Short Hosp.	ED	Obs.	Short Hosp.
Cost per Equivalent Patient	€ 115,92	€ 102,01	€ 688,64	€ 41,68	€ 28,52	€ 184,83

We can observe that the cost for a white code might vary from a minimum of 4128,07 52 € to a maximum of 696688,24 64 € depending on the weight, the cost computation methodology and on the outcome of his clinical pathway. The 696688,24 64 value refers to the cost for an hospitalized equivalent patient, under hypothesis 1, which is hospitalized. However no white codes are short hospitalized in the week we are considering. To this extent is possible to assess that the minimum cost that the short hospitalization has to cope with is that related to the green code. The green code patient costs 717,561756,03 under hypotesis 1 and € 527,85471,32 under hypoithesis 2.

We are persuaded that a standard cost definition is the necessary tool in the direction of a prospective reimbursement scheme implementation (based on tariffs) also with reference to the ED activity. As the economic literature has shown, a prospective payment (based on standard cost) would be the most effective incentive to induce efficiency in health care provision.

5. Results and discussion

In the present paper a self-reported work-sampling was implementedin order to define a weight function to be applied to calculate the actual patient cost with reference to ED activity.This issue represents one of the most relevant aspect of originality of this work. It emerges a great variability “between and within” the different types of patients depending also on the outcome, the patient severity and the health treatment structure.

We believe that this kind of analysis well fits the federalizing process that Italy is experiencing. In fact the federal reform is driving our Country toward a decentralized provision and funding of local public services. The health care services are “fundamental” under the provisions of the law that in turn implies that a standard cost has to be defined for its funding. The standard cost (as it is defined by the law) relies on the concepts of appropriateness and efficiency in the production of the health care service, assuming a standard quality level as target. The identification and measurement of health care costs is therefore a crucial task propaedeutic to health services economic evaluation. Various guidelines with different amount of details have been set up for costing methods which, however, are defined in simplified frameworks and using fictious data. This study is a first attempt to proceed, using real data, in the direction of a precise definition of the costs inherent to the emergency department activity.

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