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Quick diagnosis units: predictors of time to diagnosis and costs

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Abstract

Financial crisis has forced health systems to seek alternatives to hospitalization-based healthcare. Quick diagnosis units (QDUs) are cost-effective compared to hospitalization, but the determinants of QDU costs have not been studied.

We aimed at assessing the predictors of costs of a district hospital QDU (Hospital Plató, Barcelona) between 2009 and 2016.

This study was a retrospective longitudinal single center study of 404 consecutive outpatients referred to the QDU of Hospital Plató. The referral reason was dichotomized into suggestive of malignancy vs other. The final diagnosis was dichotomized into organic vs nonorganic and malignancy vs nonmalignancy. All individual resource costs were obtained from the finance department to conduct a micro-costing analysis of the study period.

Mean age was 62 ± 20 years (women = 56%), and median time-to-diagnosis, 12 days. Total and partial costs were greater in cases with final diagnosis of organic vs nonorganic disorder, as it was in those with symptoms suggestive or a final diagnosis of cancer vs noncancer. Of all subcosts, imaging showed the stronger correlation with total cost. Time-to-diagnosis and imaging costs were significant predictors of total cost above the median in binary logistic regression, with imaging costs also being a significant predictor in multiple linear regression (with total cost as quantitative outcome).

Predictors of QDU costs are partly nonmodifiable (i.e., cancer suspicion, actually one of the goals of QDUs). Yet, improved primary-care-to-hospital referral circuits reducing time to diagnosis as well as optimized imaging protocols might further increase the QDU cost-effectiveness process. Prospective studies (ideally with direct comparison to conventional hospitalization costs) are needed to explore this possibility.

Abbreviations: CI = confidence interval, Q1–Q3 = inter-quartile range, QDU = quick diagnosis unit.

Keywords: direct costs, indirect costs, micro-costing, public health system, quick diagnosis units

1. Introduction

Lessons learned from the last economic crisis allowed to better understand that to maximize outcomes that matter to patients, the affordability and sustainability of public health systems could only be achieved by undertaking deep reforms. In some European countries, such reforms included not funding tests and treatments lacking evidence of its value (as in the case of the National Institute of Clinical Excellence guides[1] in the United Kingdom). In Spain, the economic crisis did not result in structural changes in the health system, because these changes would probably take too long in the setting of short political terms. Accordingly, almost all policies have been contingence actions to reduce costs.[2,3] While some of these actions proved successful, like the use of generic drug policy, which led to lowering of drug prices, or exclusion from public funding of drugs lacking enough evidence of benefit, other policies had negative results.[4,5] This is the case of copayment without exclusion of frail population, reduction of salaries of health workers, or higher taxes to health products. These negative effects have rebounded on healthcare quality and its indicators such as waiting lists or times between diagnosis and treatment. Other factors with a negative impact on the sustainability of the health system include structural debts, an increasing incidence of chronic conditions, the aging of the

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population, expensive ancillary tests (and their use without standardized proceedings), and excessive medicalization.

An important avenue to facilitate the sustainability of public health systems has been the implementation of alternatives to hospitalization-based medicine.[6] Well-established examples include alternatives to hospitalization for treatment and follow-up such as ambulatory surgery, hospital at-home, day-care hospitals and telemedicine, or, for diagnosis, most notably quick diagnosis units (QDUs).

In terms of QDU, the first reported experience took place in the United Kingdom, at the Queen Elizabeth Hospital, in Birmingham, where an outward approach for cancer diagnoses was proposed, based on specialty doctors visit according to main symptoms. In Catalonia, the QDU started on 1996, when the results of the UK QDU were published.[7] It is known that around 15% to 20% of Spanish Internal Medicine admissions are for diagnostic purposes.[8,9] Thus such admissions could be potentially avoided or diminished. Internal medicine specialists lead Catalan QDUs, which gives a wide approach to the patients who usually have nonspecific symptoms (as usually happens at time of cancer presentation).

Over the last 15 years several QDUs have been set up in Catalonia as a mean of reaching diagnoses rapidly and without the problems and costs related to hospitalization[10]. There are QDUs in almost all types of hospitals, from university (like Hospital Clínic de Barcelona)[11] to small district ones (like Hospital Plató)[12]. Despite the spread of these QDUs, the available evidence on their activity and the predictors of their time-to-diagnosis and cost outcomes is scanty, particularly in the case of nonuniversity, nontertiary centers. The QDU of Hospital Plató was created in 2009 and is integrated in the Internal Medicine Department of this hospital and the Hospital Clínic is its reference center. We recently published a descriptive study of the activity of a district hospital QDU (Hospital Plató) over a 6-year time (2009–2016), comparing it to a reference university hospital QDU (Hospital Clínic de Barcelona's QDU). The main finding was that despite clear-cut differences between these hospitals, both had a similar effectiveness. However, in that study, we did not tackle time to diagnosis, costs, and their predictors.

The main objective of the present study was to describe the time to diagnosis and the costs of the QDU of a district hospital (Hospital Plató) with focus on the general costs of the QDU patients visited in this unit during a 7-year study period. We also aimed at assessing the potential predictors of longer time-to-diagnosis and greater costs. We hypothesized that while organic conditions in general and cancer in particular are more costly than nonorganic and noncancer cases, respectively, the latter increase time-to-diagnosis and result in avoidable costs. We also hypothesized that part of the diagnostic tests drives the increase in cost per case, offering an avenue for protocolling their use and potentially allowing for further reduction in time-to-diagnosis and cost-reduction.

2. Materials and methods

2.1. Setting

This study was conducted in the QDU of an urban district hospital (Hospital Plató) in Barcelona, Catalonia, Spain. This center has 160 beds for acute patients and is the healthcare provider for a population of 140,000 inhabitants. The unit evaluates patients with suspected severe conditions whose physical performance allows them to travel from home to hospital and back for visits and examinations. Similar to inpatients, diagnostic tests are preferentially arranged.

2.2. Study design and population

This is a retrospective longitudinal study of 404 consecutive patients aged ≥ 18 years who were referred to QDU between November 2009 and December 2016.

The study was approved by the research ethics committee of the network of hospitals to which Hospital Plató belongs (CEIC-Unió Catalana d'Hospitals). The need for informed consent was waived for QDU patients due to the retrospective design.

2.3. Database

Data from all the patients evaluated were recorded onto case report forms and codified in a database. The variables recorded were the same as reported elsewhere.[12] The information on the number and dates of the appointments at the QDU and the diagnostic tests as well as the reason for referral and the final diagnosis were obtained from the hospital electronic clinical records. The referral reason was dichotomized into clinical or paraclinical features suggestive of malignancy vs other referral reasons (see supplementary material, http://links.lww.com/MD/E593) for statistical analyses purposes. Likewise, the final diagnosis was dichotomized into organic vs nonorganic (organic pathology defined as when symptoms and signs have a biologic explanation and it is found during the diagnostic process) and as malignancy vs nonmalignancy. Additionally, the micro-costing study was carried out retrospectively to know the cost of each patient evaluated at the QDU, considering all the diagnostic tests performed and its costs to the hospital according to the finance department of the hospital. The costs of all the resources identified were also obtained from the finance department. Staff time dedicated to QDU was obtained according to the cumulative time dedicated to this unit, multiplied by the average hourly wage of the staff category. The same was done with other involved health professionals times. The costs of small and big consumables were included when indicated. The costs of diagnostic procedures such as laboratory tests, radiology explorations, or endoscopies were directly calculated using the unit cost of the test to the hospital. Accordingly, the variables of cost per each procedure, as well as the indirect costs and finally the total cost per each case were introduced in the database. The latter (the total cost per case) was the main outcome variable of the study and as such for statistical analyses purposes it was treated both as a quantitative variable and dichotomized according to the median of the study cohort.

2.4. Statistical analysis

Descriptive statistics of qualitative variables are expressed as absolute and relative frequencies, and those of quantitative variables are presented as mean values with standard deviations and median values with inter-quartiles (Q1−Q3). Qualitative variables were compared by means of Chi-squared or Fisher exact test. All quantitative variables were compared by means of Mann–Whitney U test due to skewed distribution of these variables. Linear correlations were checked for with Spearman test. To identify predictors of the total cost, we carried out

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multiple linear regression analyses (with total cost as quantitative dependent variable) and binary logistic regression analyses (with total cost dichotomized as detailed above as binary dependent variable). In these multiple linear and binary logistic regression models, several clinical and partial cost variables were introduced as potential predictors. These were selected after the a priori hypotheses and also due to significant unadjusted bivariate linear correlation with the outcome variable. The multiple linear regression analysis results are presented as the beta and B coefficients (the latter with their 95% confidence intervals [CIs]) and the binary logistic regression models are expressed with their

respective odds ratios and 95% CIs. The threshold for significance was set at $P < .05$ (all tests 2-tailed). All analyses were performed with SPSS version 23 (IBM, New York City, NY).

3. Results

3.1. Descriptive analysis of the entire cohort

Two hundred twenty-seven of the subjects were women (56%). Mean age was 62 ± 20 years and the median time-to-diagnosis

Table 1

Descriptive statistics of the entire QDU cohort from Hospital Plató.

	Entire cohort (n = 406)	Man	Women	P value
Sex (women)	227 (56%)	179	227	NA
Age, yrs	62 ± 20	62.48 ± 19.88	61.33 ±− 19.65	.46
	65 (46–78)	66.00 (50.0–79.0)	64 (45–78)	
Time-to-diagnosis, d	23 ± 34	26.82 ± 39.72	20.52 ± 29.41	.34
	12 (1–28)	14 (0.0–32.75)	10 (2–28)	
Referral reason (cancer suggestive features)	106 (26%)	55 (31%)	51 (22%)	.07
Final diagnosis (organic cause)	319 (79%)	140 (78%)	179 (79%)	.69
Final diagnosis (cancer)	58 (14%)	27 (15%)	31 (14%)	.78
Physician costs	38.20 ± 13.50	38.47 ± 13.65	37.98 ± 13.40	.71
	36.37 (24.25–48.50)	36.37 (24.25–48.50)	36.37 (24.25–48.50)	
Laboratory costs	108.09 ± 93.57	111.83 ± 102.91	105.14 ± 85.60	.48
	146.92 (0.00–146.92)	146.92 (0.00–146.92)	146.92 (0.00–146.92)	
Imaging costs	129.45 ± 284.19	139.48 ± 340.08	121.54 ± 231.29	.75
	16.68 (0.00–160.26)	19.10 (0.00–195.66)	16.68 (0.00–144.91)	
Cytology/biopsy costs	15.01 ± 60.85	17.89 ± 66.27	12.74 ± 56.26	.40
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Pathology costs	1.95 ± 4.37	2.01 ± 4.46	1.90 ± 4.31	.90
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Other medical consultation costs	6.51 ± 10.89	6.64 ± 10.84	6.41 ± 10.96	.77
	0.00 (0.00–24.25)	0.00 (0.00–24.25)	0.00 (0.00–24.25)	
Endoscopy costs	21.75 ± 60.23	19.02 ± 57.09	23.91 ± 62.65	.43
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Surgeon consultation costs	2.87 ± 7.84	3.12 ± 8.14	2.67 ± 7.61	.57
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Anesthetist consultation costs	4.75 ± 11.90	4.24 ± 11.35	5.16 ± 12.33	.44
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Operation room costs	4.29 ± 50.08	1.81 ± 24.24	6.25 ± 63.43	.44
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Admissions costs	40.12 ± 390.65	47.73 ± 485.39	34.11 ± 310.32	.77
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Costs of referral to tertiary hospital	4.91 ± 35.40	6.60 ± 43.44	3.58 ± 27.50	.31
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Structural costs	5.08 ± 2.64	5.14 ± 2.66	5.03 ± 2.62	.63
	4.73 (2.37–7.10)	4.73 (2.37–7.10)	4.73 (2.37–7.10)	
Indirect costs type 1	2.05 ± 1.22	2.06 ± 1.17	2.04 ± 1.26	.64
	1.71 (1.14–2.57)	1.71 (0.86–2.57)	1.71 (1.24–2.57)	
Indirect costs type 2	0.44 ± 0.32	0.44 ± 0.30	0.44 ± 0.34	.70
	0.33 (0.28–0.49)	0.33 (0.16–0.49)	0.33 (0.33–0.49)	
Indirect costs type 3	2.66 ± 1.46	2.68 ± 1.43	2.64 ± 1.48	.60
	2.35 (1.36–3.52)	2.35 (1.17–3.52)	2.35 (1.42–3.52)	
Indirect costs type 4	7.24 ± 3.68	7.33 ± 3.79	7.17 ± 3.59	.70
	6.94 (3.47–9.20)	6.94 (3.47–10.00)	6.94 (3.47–9.20)	
Indirect costs type 5	0.99 ± 0.51	0.10 ± 0.52	0.98 ± 0.51	.58
	0.91 (0.47–1.37)	0.91 (0.46–1.37)	0.91 (0.47–1.37)	
Total cost, €	394,21 ± 582.64	417.45 ± 671.17	375.86 ± 502.77	.92
	259.97 (141.13–451.25)	237.55 (149.25–461.24)	263.53 (136.98–441.24)	

Data expressed as n (%) or mean ± standard deviation and median (interquartile range).
Indirect cost type 1 = activity-related outpatient unitary drug cost, indirect cost type 2 = remainder drug cost split across healthcare episodes, indirect cost type 3 = activity-adjusted unitary outpatients' material cost, indirect cost type 4 = activity-adjusted unitary material cost of other units supporting the quick diagnosis unit (QDU) activity, indirect cost type 5 = remainder material costs split across healthcare episodes, NA = not applicable.

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Table 2

Comparative statistics between cases referred due to cancer suggestive features vs other symptoms.

	Cancer suggestive features (n=106)	Other symptoms (n=300)	P value
Sex (women)	51 (48%)	176 (59%)	.07
Age, yrs	62.24 ± 19.71	61.7 ± 19.78	.79
	69 (46–77.5)	65 (46–78)	
Time-to-diagnosis, d	19.53 ± 26.12	24.63 ± 36.87	.97
	12 (5.00–25.75)	12 (0–30)	
Final diagnosis (organic cause)	86 (81%)	233 (78%)	.46
Final diagnosis (cancer)	37 (35%)	21 (7%)	<.000001[*]
Physician costs	41.06 ± 13.75	37.18 ± 13.28	.004[*]
	36.37 (36.37–48.50)	36.37 (24.25–45.47)	
Laboratory costs	115.07 ± 115.42	105.61 ± 84.60	.30
	146.92 (0.00–146.92)	146.92 (0.00–146.92)	
Imaging costs	264.35 ± 441.82	81.79 ± 179.20	<.000001[*]
	137.78 (0.00–301.81)	0.00 (0.00–109.13)	
Cytology/biopsy costs	43.00 ± 96.76	5.12 ± 36.77	<.000001[*]
	0.00 (0.00–39.75)	0.00 (0.00–0.00)	
Pathology costs	4.03 ± 5.79	1.21 ± 3.47	<.000001[*]
	0.00 (0.00–7.83)	0.00 (0.00–0.00)	
Other medical consultation costs	8.01 ± 11.94	5.98 ± 10.47	.13
	0.00 (0.00–24.25)	0.00 (0.00–0.00)	
Endoscopy costs	25.05 ± 64.58	20.59 ± 58.70	.52
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Surgeon consultation costs	5.26 ± 10.04	2.02 ± 6.71	<.000001[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Anesthetist consultation costs	6.50 ± 13.55	4.14 ± 11.22	.08
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Operation room costs	6.23 ± 45.14	3.61 ± 51.77	.27
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Admissions costs	22.67 ± 208.83	46.28 ± 444.58	.69
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Costs of referral to tertiary hospital	2.35 ± 24.18	5.81 ± 38.59	.24
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Structural costs	5.62 ± 2.70	4.89 ± 2.59	.02[*]
	4.73 (4.73–7–10)	4.73 (2.37–6.51)	
Indirect costs type 1	2.27 ± 1.23	1.97 ± 1.21	.007[*]
	1.71 (1.71–2.57)	1.71 (0.86–2.55)	
Indirect costs type 2	0.49 ± 0.32	0.42 ± 0.32	.01[*]
	0.33 (0.33–0.65)	0.33 (0.16–0.49)	
Indirect costs type 3	2.95 ± 1.47	2.56 ± 1.44	.005[*]
	2.35 (2.35–3.52)	2.35 (1.17–3.44)	
Indirect costs type 4	8.04 ± 3.77	6.96 ± 3.60	.003[*]
	6.94 (6.13–10.40)	6.94 (3.47–8.64)	
Indirect costs type 5	1.09 ± 0.52	0.95 ± 0.50	.008[*]
	0.91 (0.91–1.37)	0.91 (0.46–1.26)	
Total cost, €	564.06 ± 595.02	334.20 ± 567.13	<.000001[*]
	430.75 (200.26–769.33)	220.87 (118.04–389.36)	

Data expressed as n (%) or mean ± standard deviation and median (interquartile range).

Indirect cost type 1 = activity-related outpatient unitary drug cost, indirect cost type 2 = remainder drug cost split across healthcare episodes, indirect cost type 3 = activity-adjusted unitary outpatients' material cost, indirect cost type 4 = activity-adjusted unitary material cost of other units supporting the quick diagnosis unit activity, indirect cost type 5 = remainder material costs split across healthcare episodes.

[*] Statistically significant differences.

was 12 days. Around one quarter of the cases were referred due to cancer suggestive features and most of the patients received a final diagnosis of an organic disorder, but of those, <20% were cancer. The median total cost was 259.97€ (for the partial costs, see Table 1). When comparing all the study variables according to sex, there were no statistically significant differences (Table 2).

3.2. Comparison of demographic, clinical, and costs data according to referral reason and final diagnosis
3.2.1. Referral due to cancer vs noncancer suggestive features. These 2 subgroups did not statistically differ in either

sex, age, time to diagnose, or the proportion of organic final diagnosis. Nevertheless, the proportion of cases with a final diagnosis of cancer was 5 times greater in patients referred for cancer-suggestive feature. In terms of costs, both the total cost and several partial costs (imaging, cytology, pathology, surgical, structural and indirect costs) were significantly greater in cases referred due to cancer suggestive features (Table 2).

3.2.2. Organic vs nonorganic final diagnosis. As in the previous case, there were no differences in basic demographic and clinical data. The proportion of cancer cases was significantly greater in the former group than in the latter. In patients with a

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Table 3

Comparative statistics between final organic vs nonorganic diagnosis.

	Organic final diagnose (n = 319)	Nonorganic final diagnose (n = 72)	P value
Sex (women)	179 (56%)	38 (53%)	.69
Age, yrs	62.26 ± 19.44	59.57 ± 21.41	.38
	65 (48–78)	62.5 (43–79)	
Time-to-diagnosis, d	23.29 ± 35.26	22.65 ± 29.76	.91
	12 (1.75–28.25)	13 (0.50–27.75)	
Referral reason (cancer suggestive features)	86 (27%)	16 (22%)	.46
Final diagnosis (cancer)	58 (18%)	0 (0%)	.000004[*]
Physician costs	38.27 ± 13.15	36.21 ± 10.86	.33
	36.37 (24.25–48.50)	36.37 (24.25–36.37)	
Laboratory costs	110.16 ± 97.31	97.39 ± 75.16	.73
	146.92 (0.00–146.92)	146.92 (0.00–146.92)	
Imaging costs	138.55 ± 306.34	64.37 ± 93.28	.10
	16.68 (0.00–179.84)	0.00 (0.00–109.13)	
Cytology/biopsy costs	19.02 ± 68.11	0.00 ± 0.00	.002[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Pathology costs	2.35 ± 4.71	0.22 ± 1.30	<.000001[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Other medical consultation costs	7.60 ± 11.43	2.02 ± 6.75	<.000001[*]
	0.00 (0.00–24.25)	0.00 (0.00–0.00)	
Endoscopy costs	24.72 ± 63.63	7.66 ± 37.01	.030[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Surgeon consultation costs	3.42 ± 8.45	0.34 ± 2.86	.003[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Anesthetist consultation costs	3.40 ± 12.55	1.44 ± 6.94	.010[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Operation room costs	5.47 ± 56.47	0.00 ± 0.00	.34
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Admissions costs	51.06 ± 447.01	0.00 ± 0.00	.24
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Costs of referral to tertiary hospital	6.25 ± 39.85	0.00 ± 0.00	.13
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Structural costs	5.09 ± 2.57	4.70 ± 2.12	.23
	4.73 (2.37–7.10)	4.73 (2.37–4.73)	
Indirect costs type 1	2.08 ± 1.21	1.76 /- 0.83	.13
	1.71 (1.24–2.57)	1.71 (0.86–1.71)	
Indirect costs type 2	0.45 ± 0.32	0.35 ± 1.19	.03[*]
	0.33 (0.33–0.49)	0.33 (0.16–0.33)	
Indirect costs type 3	2.68 ± 1.44	2.37 ± 1.08	.08
	2.35 (1.42–3.52)	2.35 (1.17–2.35)	
Indirect costs type 4	7.24 ± 3.56	6.82 ± 3.08	.86
	6.94 (3.47–9.20)	6.94 (3.47–6.94)	
Indirect costs type 5	0.99 ± 0.50	0.91 ± 0.41	.11
	0.91 (0.47–1.37)	0.91 (0.46–0.91)	
Total cost, €	427.07 ± 639.20	226.55 ± 148.88	.03[*]
	274.35 (149.25–484.22)	216.94 (58.49–330.36)	

Data expressed as n (%) or mean ± standard deviation and median (interquartile range).
Indirect cost type 1 = activity-related outpatient unitary drug cost, indirect cost type 2 = remainder drug cost split across healthcare episodes, indirect cost type 3 = activity-adjusted unitary outpatients' material cost, indirect cost type 4 = activity-adjusted unitary material cost of other units supporting the quick diagnosis unit activity, indirect cost type 5 = remainder material costs split across healthcare episodes.
[*] Statistically significant differences.

final diagnosis of an organic disorder, the total and partial (cytology, pathology, medical consultations, endoscopy, and surgical and anaesthetist costs) costs were significantly greater than in patients with a nonorganic disorder diagnosis (Table 3).

3.2.3. Cancer vs noncancer final diagnosis.
In this set of comparisons, cases with a final cancer diagnosis were significantly older and had a greater proportion of referrals due to cancer suggestive features. Cancer cases exhibited significantly greater total costs, mainly due to significantly greater partial costs in the following areas: physician costs, imaging, cytology,

pathology, other medical consultations, surgeon and anaesthetist consultations, operation room, admissions and indirect costs (Table 4).

3.3. Comparison of demographic, clinical, and partial costs data according to time-to-diagnosis and total cost
3.3.1. Time-to-diagnosis greater vs smaller than the cohort median.
These 2 groups did not differ in any of the demographic or clinical variables. The group with a prolonged diagnostic time had significantly greater costs, both total and the following partial costs: physician and laboratory costs, imaging, pathology,

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Table 4

Comparative statistics between final diagnosis of cancer vs noncancer.

	Cancer final diagnose (n = 58)	Noncancer final diagnose (n = 331)	P value
Sex (women)	31 (53%)	184 (56%)	.78
Age, yrs	68.28 ± 15.96	60.51 ± 20.22	.01[*]
	71.5 (61.00–79.25)	64 (45–77)	
Time-to-diagnosis, d	13.33 ± 14.81	24.86 ± 36.57	.15
	8 (2–21)	12 (1–31)	
Referral reason (cancer suggestive features)	37 (64%)	64 (19%)	<.000001[*]
Final diagnosis (organic cause)	58 (100%)	258 (78%)	.000004[*]
Physician costs	42.02 ± 15.10	37.11 ± 12.21	.02[*]
	36.37 (36.37–48.50)	36.37 (24.25–48.50)	
Laboratory costs	115.77 ± 134.92	105.73 ± 85.01	.93
	146.92 (0.00–146.92)	146.92 (0.00–146.92)	
Imaging costs	387.83 ± 584.62	78.65 ± 141.24	<.000001[*]
	218.26 (0.00–593.05)	8.34 (0.00–113.02)	
Cytology/biopsy costs	72.57 ± 125.77	5.62 ± 33.63	<.000001[*]
	0.00 (0.00–86.53)	0.00 (0.00–0.00)	
Pathology costs	6.79 ± 6.47	1.12 ± 3.25	<.000001[*]
	7.83 (0.00–12.89)	0.00 (0.00–0.00)	
Other medical consultation costs	11.29 ± 13.02	5.79 ± 10.35	.001[*]
	0.00 (0.00–24.25)	0.00 (0.00–0.00)	
Endoscopy costs	32.87 ± 72.71	19.18 ± 56.79	.10
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Surgeon consultation costs	7.53 ± 11.32	2.05 ± 6.76	<.000001[*]
	0.00 (0.00–24.25)	0.00 (0.00–0.00)	
Anesthetist consultation costs	8.32 ± 14.88	3.96 ± 11.01	.009[*]
	0.00 (0.00–8.62)	0.00 (0.00–0.00)	
Operation room costs	9.44 ± 51.73	3.61 ± 51.09	.049[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Admissions costs	105.88 ± 561.27	30.65 ± 371.14	.015[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Costs of referral to tertiary hospital	0.00 ± 0.00	6.02 ± 39.13	.18
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Structural costs	5.79 ± 2.98	4.87 ± 2.38	.12
	4.73 (4.73–7.10)	4.73 (2.37–7.10)	
Indirect costs type 1	2.38 ± 1.26	1.95 ± 1.13	.015[*]
	1.71 (1.71–2.57)	1.71 (0.86–2.57)	
Indirect costs type 2	0.52 ± 0.32	0.42 ± 0.30	.005[*]
	0.33 (0.33–0.65)	0.33 (0.16–0.49)	
Indirect costs type 3	3.07 ± 1.56	2.54 ± 1.34	.004[*]
	2.35 (2.35–3.52)	2.35 (1.17–3.52)	
Indirect costs type 4	8.27 ± 4.23	6.95 ± 3.30	.040[*]
	6.94 (6.13–10.40)	6.94 (3.47–9.29)	
Indirect costs type 5	1.13 ± 0.57	0.95 ± 0.46	.014[*]
	0.91 (0.91–1.37)	0.91 (0.46–1.37)	
Total cost, €	821.48 ± 955.51	313.55 ± 457.80	<.000001[*]
	529.07 (200.26–1048.33)	222.57 (117.90–400.74)	

Data expressed as n (%) or mean ± standard deviation and median (interquartile range).
Indirect cost type 1 = activity-related outpatient unitary drug cost, indirect cost type 2 = remainder drug cost split across healthcare episodes, indirect cost type 3 = activity-adjusted unitary outpatients' material cost, indirect cost type 4 = activity-adjusted unitary material cost of other units supporting the quick diagnosis unit activity, indirect cost type 5 = remainder material costs split across healthcare episodes.
[*] Statistically significant differences.

other medical consultations, endoscopy, anaesthetist consultation, structural cost, and all the indirect costs (Table 5).

3.3.2. Total cost greater vs smaller than the cohort median.
Cases with a highest total cost had a significantly longer time to the diagnosis and a greater proportion of cases referred due to cancer suggestive features, as well as more organic and cancer final diagnoses. Almost all partial costs were greater in the former than in the latter group, most remarkably for imaging costs, both in absolute and relative terms (Table 6).

3.4. Cost correlation and regression analyses

Of all the demographic and clinical variables, only time-to-diagnosis significantly but modestly showed a lineal correlation with total costs (Fig. 1). In terms of partial costs correlations with total costs, all correlations were significant, with the linear correlation between imaging and total costs being the strongest one (Table 7, Fig. 2).

In the binary logistic regression model with total cost dichotomized according to the median as dependent variable, and with sex, age, referral due to cancer suggestive features, time-

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Comparative statistics between cases with time-to-diagnosis over vs under the median time-to-diagnosis.

	Time > 12 d (n = 190)	Time ≤ 12 d (n = 198)	P value
Sex (women)	99 (52%)	117 (59%)	.18
Age, yrs	61.84 ± 19.27	61.77 ± 20.45	.95
	66 (46–78)	64 (45–79)	
Referral reason (cancer suggestive features)	48 (25%)	52 (26%)	.91
Final diagnosis (organic cause)	155 (82%)	163 (82%)	.89
Final diagnosis (cancer)	23 (12%)	34 (17%)	.20
Physician costs	45.31 ± 13.17	30.99 ± 7.67	<.000001[*]
	36.37 (36.37–48.50)	24.25 (24.25–36.37)	
Laboratory costs	134.08 ± 79.62	79.96 ± 77.12	<.000001[*]
	146.92 (118.60–146.92)	95.91 (0.00–146.92)	
Imaging costs	177.94 ± 350.17	73.94 ± 181.46	<.000001[*]
	87.93 (0.00–218.26)	0.00 (0.00–79.28)	
Cytology/biopsy costs	16.61 ± 62.03	14.70 ± 62.45	.27
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Pathology costs	2.61 ± 4.99	1.32 ± 3.60	.002[*]
	0.00 (0.00–7.83)	0.00 (0.00–0.00)	
Other medical consultation costs	7.78 ± 11.62	5.39 ± 10.11	.036[*]
	0.00 (0.00–24.25)	0.00 (0.00–0.00)	
Endoscopy costs	29.68 ± 68.76	13.21 ± 48.03	.006[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Surgeon consultation costs	3.06 ± 8.07	2.69 ± 7.64	.64
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Anesthetist consultation costs	6.53 ± 13.55	2.79 ± 9.42	.002[*]
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Operation room costs	7.41 ± 69.01	1.70 ± 23.87	.30
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Admissions costs	63.24 ± 541.83	21.58 ± 201.95	.95
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Costs of referral to tertiary hospital	7.53 ± 45.71	2.85 ± 23.65	.18
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Structural costs	6.47 ± 2.57	3.67 ± 1.50	<.000001[*]
	4.73 (4.73–7.10)	2.37 (2.37–4.73)	
Indirect costs type 1	2.62 ± 1.27	1.46 ± 0.66	<.000001[*]
	2.48 (1.71–3.07)	1.24 (0.86–1.71)	
Indirect costs type 2	0.57 ± 0.35	0.31 ± 0.18	<.000001[*]
	0.49 (0.33–0.65)	0.33 (0.16–0.33)	
Indirect costs type 3	3.39 ± 1.47	1.91 ± 0.81	<.000001[*]
	2.85 (2.35–3.89)	1.42 (1.17–2.35)	
Indirect costs type 4	9.20 ± 3.55	5.26 ± 2.14	<.000001[*]
	6.94 (6.94–10.40)	3.47 (3.47–6.94)	
Indirect costs type 5	1.26 ± 0.50	0.71 ± 0.29	<.000001[*]
	0.94 (0.91–1.39)	0.47 (0.46–0.91)	
Total cost, €	519.00 ± 728.30	264.43 ± 365.65	<.000001[*]
	359.99 (220.87–532.64)	179.69 (53.34–323.61)	

Data expressed as n (%) or mean ± standard deviation and median (interquartile range).
Indirect cost type 1 = activity-related outpatient unitary drug cost, indirect cost type 2 = remainder drug cost split across healthcare episodes, indirect cost type 3 = activity-adjusted unitary outpatients' material cost, indirect cost type 4 = activity-adjusted unitary material cost of other units supporting the quick diagnosis unit activity, indirect cost type 5 = remainder material costs split across healthcare episodes.
[*] Statistically significant differences.

to-diagnosis and imaging cost as independent variables or predictors, only time-to-diagnosis and imaging cost were significantly associated with a greater cost (Table 8).

In the multiple linear regression model considering total cost as a quantitative variable and the outcome, and the same variables as above as the predictors, only the imaging costs were independent predictors (beta = 0.656, B = 1.365, 95% CI = 1.198–1.531, P < .0001).

4. Discussion

In this single-center retrospective longitudinal study carried out at a district hospital, we have observed that the cost of patients

referred due to cancer suggestive symptoms was greater than that of those with other referral reasons. Likewise, a final cancer diagnosis also implied a higher cost than other noncancer diagnoses. Longer time-to-diagnosis was associated with greater costs too. Of all subcosts relative to the different procedures, ancillary tests and consultations, the one showing a stronger correlation with total cost was the imaging cost. Both time-to-diagnosis and imaging cost were significant predictors of total costs in binary logistic regression, with imaging costs being a significant predictor in multiple linear regression.

Despite the study limitations (retrospective analysis and single-center setting), its design is distinct due to the use of the micro-costing approach. Micro-costing consists in a comprehensive and

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Table 6

Comparative statistics between cases with total cost over vs under the median of the total cost.

	Cost >259.97€ (n=203)	Cost ≤259.97€ (n=203)	P value
Sex (women)	116 (57%)	111 (55%)	.69
Age, yrs	62.49 ± 18.26	61.19 ± 21.14	.79
	66 (50–77)	64 (45–80)	
Time-to-diagnosis, d	31.48 ± 32.78	15.31 ± 34.27	<.000001*
	21.00 (8.00–42.50)	6.00 (0.00–14.75)	
Referral reason (cancer suggestive features)	74 (36%)	32 (16%)	.000003*
Final diagnosis (organic cause)	166 (82%)	153 (75%)	.050*
Final diagnosis (cancer)	43 (21%)	15 (7%)	.00005*
Physician costs	44.62 ± 14.83	31.78 ± 7.90	<.000001*
	36.37 (36.37–48.50)	36.37 (24.25–36.37)	
Laboratory costs	152.03 ± 93.80	64.14 ± 69.81	<.000001*
	146–92 (146.92–146.92)	0.00 (0.00–146.92)	
Imaging costs	247.24 ± 364.72	11.66 ± 31.91	<.000001*
	150.83 (49.02–283.96)	0.00 (0.00–8.34)	
Cytology/biopsy costs	29.85 ± 83.54	0.17 ± 0.77	<.000001*
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Pathology costs	3.74 ± 5.54	0.15 ± 1.09	<.000001*
	0.00 (0.00–7.83)	0.00 (0.00–0.00)	
Other medical consultation costs	10.03 ± 12.21	2.99 ± 7.99	<.000001*
	0.00 (0.00–24.25)	0.00 (0.00–0.00)	
Endoscopy costs	43.51 ± 79.52	0.00 ± 0.00	<.000001*
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Surgeon consultation costs	4.06 ± 9.08	1.67 ± 6.16	.002*
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Anesthetist consultation costs	9.34 ± 15.36	0.17 ± 2.42	<.000001*
	0.00 (0.00–34.47)	0.00 (0.00–0.00)	
Operation room costs	8.59 ± 70.66	0.00 ± 0.00	.045*
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Admissions costs	80.23 ± 558.76	0.00 ± 0.00	.014*
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Costs of referral to tertiary hospital	8.93 ± 48.67	0.89 ± 10.57	.053
	0.00 (0.00–0.00)	0.00 (0.00–0.00)	
Structural costs	6.33 ± 2.90	3.83 ± 1.54	<.000001*
	4.73 (4.73–7.10)	4.73 (2.37–4.73)	
Indirect costs type 1	2.61 ± 1.39	1.49 ± 0.65	<.000001*
	2.47 (1.71–3.43)	1.71 (0.86–1.71)	
Indirect costs type 2	0.57 ± 0.37	0.31 ± 0.17	<.000001*
	0.49 (0.33–0.65)	0.33 (0.16–0.33)	
Indirect costs type 3	3.35 ± 1.63	1.97 ± 0.81	<.000001*
	2.85 (2.35–4.27)	2.34 (1.17–2.35)	
Indirect costs type 4	8.96 ± 4.02	5.51 ± 2.23	<.000001*
	6.94 (6.93–10.40)	6.13 (3.47–6.94)	
Indirect costs type 5	1.23 ± 0.56	0.74 ± 0.30	<.000001*
	0.94 (0.91–1.40)	0.91 (0.46–0.91)	

Data expressed as n (%) or mean ± standard deviation and median (interquartile range).
Indirect cost type 1 = activity-related outpatient unitary drug cost, indirect cost type 2 = remainder drug cost split across healthcare episodes, indirect cost type 3 = activity-adjusted unitary outpatients' material cost, indirect cost type 4 = activity-adjusted unitary material cost of other units supporting the quick diagnosis unit activity, indirect cost type 5 = remainder material costs split across healthcare episodes.
* Statistically significant differences.

case-by-case real cost analysis, as opposed to the cost-minimization analysis,[13] which assumes that average costs apply to all cases. Hence, micro-costing is a more reliable and accurate approach to assess the actual costs of a healthcare process. Indeed, micro-costing has been applied in several fields of medicine, such as thyroid surgery, liver transplantation, human immunodeficiency virus, and intensive care units care in both western and emerging countries.[14–19] In terms of QDUs, only 2 previous studies have been reported where this methodology was applied,[20,21] with both focusing on comparing the QDU costs with the costs of hospitalization for the same conditions. While micro-costing theoretically also offers an avenue to identify predictors of the total cost out of the different subcosts, to the best of our knowledge this approach has not been previously applied to identify predictors of QDU costs.

By using the micro-costing approach, both cancer suggestive symptoms and a final cancer diagnosis were associated with higher costs in our study. This observation agrees with the results of a previous cost-minimization study conducted at a university high-complexity hospital, where the estimated cost per patient for nononcologic anemia was lower than that of both lymphoma and lung cancer (anemia 652.46€; lymphoma 976.01€; lung cancer 1030.79€)[13]. Remarkably, though, under our micro-costing assessment the median costs per patient according to cancer
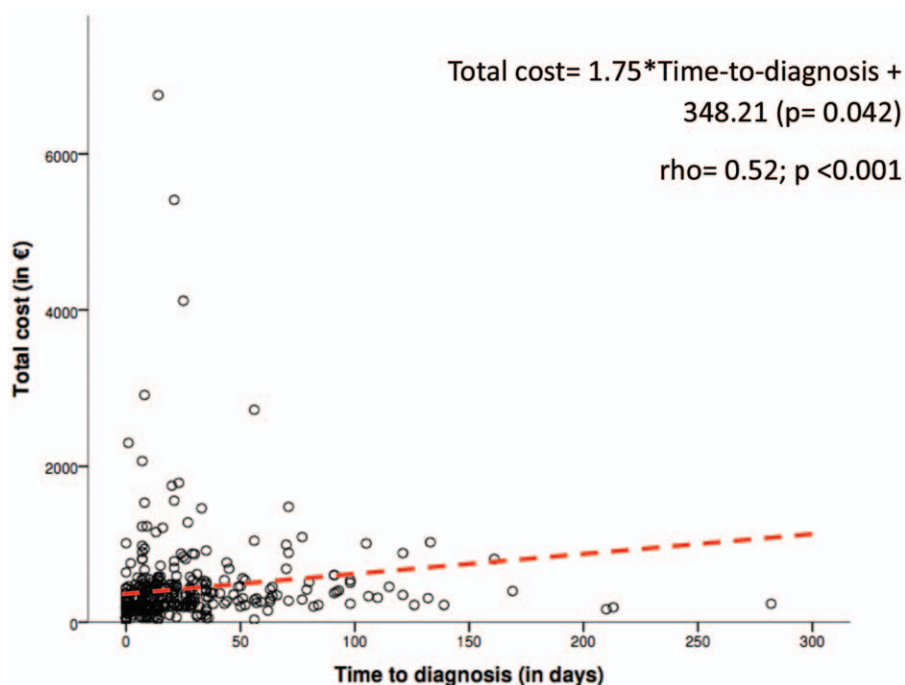
Figure 1. Correlation between cost and time-to-diagnosis.

suggestive features and a final diagnosis of cancer were 430.75€ and 529.07€, respectively. Hence, and albeit not directly comparable due to different methodologies (cost-minimization vs micro-costing) and study groups (noncancer anemia vs lymphoma and lung cancer in one case, and cancer vs noncancer in our case), this finding suggests that district hospital QDU might be more efficient than university hospital QDU.

Table 7

Correlations between partial costs and total cost (n = 406).

	Rho	P value
Physician cost	0.63	<.000001[*]
Laboratory cost	0.63	<.000001[*]
Imaging cost	0.77	<.000001[*]
Cytology/biopsy cost	0.40	<.000001[*]
Pathology cost	0.53	<.000001[*]
Other medical consultation cost	0.36	<.000001[*]
Endoscopy cost	0.37	<.000001[*]
Surgeon consultation cost	0.18	.0003[*]
Anesthetist cost	0.41	<.000001[*]
Operation room cost	0.14	.005[*]
Admissions cost	0.21	.00003[*]
Referral tertiary hospital cost	0.13	.009[*]
Structural cost	0.60	<.000001[*]
Indirect cost 1	0.62	<.000001[*]
Indirect cost 2	0.59	<.000001[*]
Indirect cost 3	0.62	<.000001[*]
Indirect cost 4	0.58	<.000001[*]
Indirect cost 5	0.62	<.000001[*]

Indirect cost type 1 = activity-related outpatient unitary drug cost, indirect cost type 2 = remainder drug cost split across healthcare episodes, indirect cost type 3 = activity-adjusted unitary outpatients' material cost, indirect cost type 4 = activity-adjusted unitary material cost of other units supporting the quick diagnosis unit activity, indirect cost type 5 = remainder material costs split across healthcare episodes.
[*] statistically significant association.

While previous studies have shown that QDU is not inferior to hospitalization in terms of time-to-diagnosis, the impact of time-to-diagnosis on costs has not been properly evaluated. In our study, the association of longer time-to-diagnosis with higher costs could be a result of longer time-to-diagnosis being a proxy of more complex cases requiring more diagnostic tests. Therefore, it is unlikely that merely reducing the time-to-diagnosis rather than the number of diagnostic tests could result in cost saving, due to the marginal contribution of personal and structural costs to the total cost of the QDU process. Nevertheless, reducing the time-to-diagnosis would still be valuable in terms of improved patient-perceived quality.

In the assessment of linear correlations between partial and total costs, all were significantly correlated, and imaging costs displayed the strongest association. Accordingly, imaging costs surfaced as a significant predictor of the total cost of the QDU process both in the binary logistic regression model considering the total costs dichotomized according to the median, and in the multiple regression model with total costs as the quantitative dependent variable. It could be argued that this association was driven by the fact that imaging tests are costly and commonly used in the QDU process. Should one conclusion of our results be that cutting imaging costs would result in QDU costs saving, this strategy would be jeopardized by the fact that most such patients do need imaging for diagnosis and staging. Nevertheless, more stringent protocols trying to avoid overuse of imaging in cases with a very low likelihood of cancer, and to limit the number of imaging tests in cases with high cancer suspicion to those strictly necessary to identify the tumor, guide the biopsy and complete the staging, might eventually overcome this challenge. There are avenues for reducing imaging cost that do not rely on avoiding a given imaging test but rather simplifying it by means of abbreviated protocols. For example, there is one such experience with abbreviated magnetic resonance imaging protocol for breast
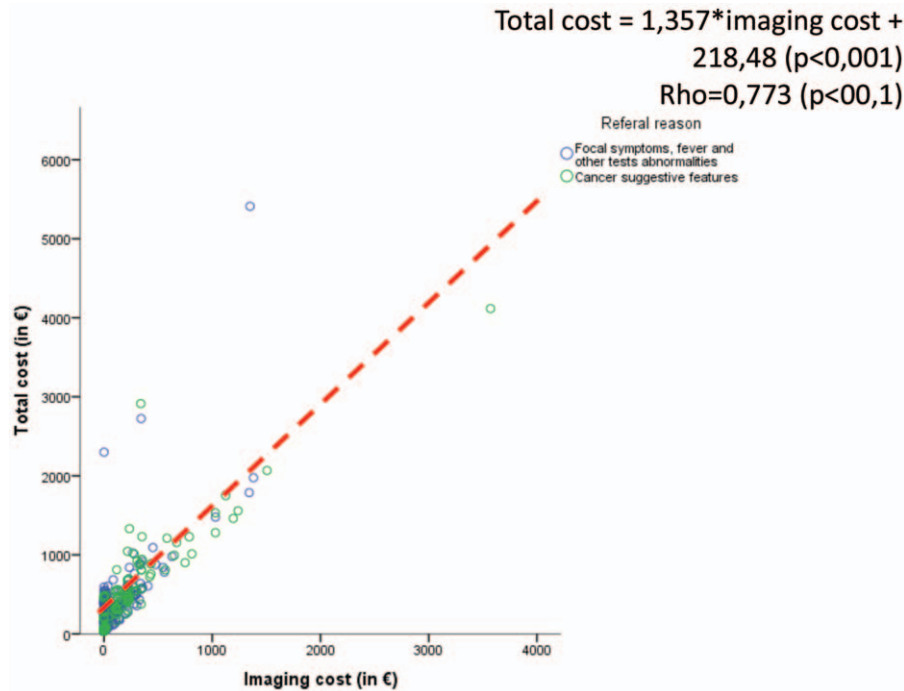
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Figure 2. Correlation between total cost and imaging cost.

Table 8

Binary logistic regressions with the total cost dichotomized according to its median value as outcome (dependent variable) and age, sex, time-to-diagnosis, referral reason, and imaging costs as potential predictors (independent variables).

Total cost dichotomized according to median	Odds ratio	95% confidence interval		P value
		Lower margin	Upper margin	
Sex (women)	0.75	0.42	1.35	.34
Age, yrs	1.00	0.99	1.02	.77
Referral reason (suggestive of cancer)	1.01	0.46	2.24	.97
Time-to-diagnosis, d	1.01	1.002	1.02	.013*
Imaging cost, €	1.03	1.02	1.03	<.001*

* statistically significant association.

cancer that has proven to reduce the imaging costs for this diagnosis.[22]

This study has both limitations and strengths. The main limitations are the retrospective design along with the fact of being a single-center study, as well as the lack of direct comparison to hospitalization costs. However, these limitations are, at least partly, compensated for by the strengths of the reasonably large sample size and the detailed micro-costing approach[23]. The latter has allowed for reliable identification of cost-predictors. This along with the prior knowledge that QDUs are cost-effective relative to conventional hospitalization[10,11] supports the notion that further cost decrease in QDU might represent an additional advantage compared to hospitalization-based diagnosis. However, studies with direct comparison will be needed to confirm or not this hypothesis. Another asset of our study is the longitudinal design with a long study period.

5. Conclusion

In summary, our study has identified a number of predictors of the total QDU costs. Some of these are only partly modifiable

such as the referral reason, because one of the goals of the QDU is actually to speed up the diagnosis of cases with features suspicious of an underlying neoplasm, which is one of the contributors to the QDU cost. Nevertheless, improved protocols and communication between the primary care centers and the hospital-based QDU might lead to a reduction of noncancer suspicious referrals, which albeit not being predictors of increased costs, do also have an impact on the cost burden. Some other predictors, mostly imaging costs, might be more addressable, even if not easily. For instance, protocols promoting lesser expensive screening tests with high negative predictive value might result in less additional and costly imaging tests. Another avenue is that of simplifying certain imaging protocols reducing the time of acquisition or the number of sequences in magnetic resonance imaging studies, for example. These actions could add to the already demonstrated cost-effectiveness of QDUs and potentially assist the sustainability of the national health systems. This could be implemented and be beneficial not only to QDUs in Spain but also in many developing nations, where healthcare systems are severely constrained by financial reasons.

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Author contributions

Alfons López-Soto: supervision, drafting the manuscript, final approval

Elisabet Montori-Palacín: data collection and analysis, drafting the manuscript, final approval

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Jordi Altés-Capella: data collection, final approval

Jordi Ramon: economic study, final approval

Monica Insa: Economic study, final approval

Rafel X Vidal-Serra: economic study, final approval

Sergio Prieto-González: data collection, final approval

Xavier Bosch: general supervision, drafting the manuscript, final approval

Yaroslau Compta: statistical analysis, drafting the manuscript, final approval

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