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### ► To cite this version:

Paul Gabarre, Pierre-Yves Boelle, Naïke Bigé, Muriel Fartoukh, Christophe Guitton, et al.. French ICU's health care workers have a poor knowledge of the cost of the devices they use for patient care: A prospective multicentric study. *Journal of Critical Care*, 2020, 56, pp.37 - 41. 10.1016/j.jcrc.2019.12.003 . hal-03488851

**HAL Id: hal-03488851**

**<https://hal.science/hal-03488851>**

Submitted on 21 Jul 2022

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**French ICU's health care workers have a poor knowledge of the cost of the devices they use for patient care: a prospective multicentric study.**

Paul Gabarre, MD<sup>1</sup>; Pierre-Yves Boelle, PhD<sup>2,3</sup>; Naïke Bigé, MD, PhD<sup>1</sup>; Muriel Fartoukh, MD, PhD<sup>2,4</sup>; Christophe Guitton, MD, PhD<sup>5</sup>; Guillaume Dumas, MD<sup>1,2</sup>; Jean-Rémi Lavillegrand, MD<sup>1,2</sup>; Geoffroy Hariri, MD<sup>1,2</sup>; Jean-Luc Baudel, MD<sup>1</sup>; Daniel Zafimahazo, MD<sup>1</sup>; Hafid Ait-Oufella, MD, PhD<sup>1,2</sup>; Eric Maury, MD, PhD<sup>1,2,3</sup>

<sup>1</sup> Service de Médecine Intensive – Réanimation

Hôpital Saint-Antoine, 75571 Paris Cedex 12

<sup>2</sup> Université Pierre-et-Marie Curie-Paris 6, Paris 6, France.

<sup>3</sup> Inserm U1136, 75012, Paris, France.

<sup>4</sup> Service de Médecine Intensive – Réanimation

Hôpital Tenon, 75020 Paris, France

<sup>5</sup> Service de Médecine Intensive – Réanimation

Centre Hospitalier, 72037 Le Mans.

Corresponding author : Pr Eric Maury, Service de Médecine Intensive-Réanimation,

Hôpital Saint-Antoine, Assistance Publique-Hôpitaux de Paris

184 rue du faubourg Saint-Antoine

75571 Paris Cedex 12

France

e-mail:eric.maury@aphp.fr

no conflict of interest

no funding

## Take Home Message

Intensive Care Unit associated costs control requires an accurate assessment of expenditures. Unfortunately, ICU HCWs have limited awareness of the prices of the devices they daily use for their patients as illustrated in this survey where less than one third of HCWs were able to estimate the cost of devices within more or less than 50% of the real price.

## **Abstract**

**Purpose:** ICU patient's care may require the use of onerous devices, which contributes to make this department one of the most expensive in the hospital. It seemed us relevant to assess healthcare workers' (HCWs) knowledge of the cost of the devices daily used in ICU.

**Materials and Methods:** An anonymous questionnaire was administered on a voluntary basis to HCWs of 3 ICUs

**Measurements and Main Results:** Cost estimations were expressed as percentage of the real cost; an estimation was considered correct if it was  $\pm 50\%$  of the true price. 107 HCWs (66 physicians and 41 nurses and nurse aids) answered the survey. Only 29% of estimations were within 50% of the real cost. The prices of the cheapest devices were overestimated, while the costs of the most expensive ones were underestimated. In multivariate analysis, cost less than 50 euros [OR=3.2; CI 95 % ( 1.6-6.3)], professional experience less than 10 years [OR= 1.5; CI 95%(1.1-2.1)], being a medical student [OR= 2.0; CI 95%(1.3-3.0)], and working in a university affiliated hospital [OR= 0.6; CI 95%(0.4-0.9)] were associated with an incorrect estimation.

**Conclusions:** ICU's HCWs have a poor knowledge of the price of devices they regularly use for the care of their patients.

**Keywords:** Cost awareness. ICU's devices. Health care cost control. Intensive Care Unit.

## **Introduction**

Intensive care unit (ICU) is the most expensive department in hospital, accounting for 15 to 20% of the hospital's expenditures representing therefore three to five times more than medical or surgical departments.

In modern medicine, patients care relies on more or less expensive devices and procedures such as ultrasonography, fiber optic endoscopy, delocalized biology and other imaging modalities such as MRI or TEP scan. Furthermore, in the most severe patients, therapeutics consuming resources might be implemented to support organ failure, such as renal replacement therapy(1), mechanical ventilation(2, 3), and extracorporeal life support which dramatically increase intensive care costs.

In this era of cost inflation reducing the cost of ICU, while preserving a high efficiency level, appears today as an evidence. However, cost containment seems difficult to obtain in ICU (4).

Controlling costs related to ICU is part of responsibility of Health Care Workers (5, 6), and making them aware of the cost of ICU procedures and devices could participate to decrease ICU dispenses by reducing numbers of prescriptions (7,8). However, in France, medical training favors physiopathology or therapeutics, but does not discuss health economy and as a consequence Health Care Workers are poorly aware of costs of patients care (5, 9). Several studies have outlined the weak knowledge physicians have of the price of both their prescription and daily equipment they used (9–12). This gap in medical curriculum might lead young doctors and medical students to waste public money by prescribing unjustified exams without cost-awareness, under the pretext of patient's benefit (5).

Similarly, paramedical staff (PM ie: nurses and nurse' aids), who manipulates in their daily practice expensive devices and high cost drugs, have limited knowledge of the cost of both imaging exam as well as single use devices used for the care of ICU patients (13). Furthermore, it can be hypothesized than being aware of the real cost of the devices could promote HCWs to be more careful during the handling of these devices.

To the best of our knowledge few studies if any have investigated physicians and paramedics knowledge of the cost of specific devices used in daily practice in ICU. Since funding of the

public hospital is mainly provided by public purse and therefore by French citizens, it seemed relevant to evaluate HCW's knowledge of the cost of the devices daily used in ICU.

## **Materiel and Methods**

### **Objective**

The aim of this study was to assess HCW's awareness of the cost of devices regularly used for ICU patients care.

### **Study design**

We conducted a prospective, multicenter, volunteer-based study. An anonymous questionnaire was proposed to HCWs of three ICUs. All categories of HCWs were invited to answer the survey: medical staff, including juniors (medical students and residents), seniors (professors, associate professors, attending physicians and fellows) and paramedical staff, including nurses and nurse's aids. Characteristics of participants were collected: age, sex, grade, length of service, facility characteristics and estimated price of devices.

### **Questionnaire**

The survey proposed to estimate the cost of 44 medical devices frequently used in daily critically ill patients care, whose price ranged from 4 euros to nearly 2 million euros, such as catheters, ultrasound devices, organ failure supportive machines (renal replacement therapy, ventilator), casual bedroom, transport equipment and radiology machines.

### **Statistical analysis**

Results are expressed as number (percentage) or mean (percentage)  $\pm$  standard deviation. Cost estimations are expressed as percentage of the real cost. A correct estimation is defined as between 50 and 150% of the real price. Two variables were compared using a t-test on XLSTAT® software. For more than two comparisons, data were compared using ANOVA. Using multivariate analysis, we determined parameters which were associated with the o of an incorrect estimation. Odds ratios (OR) were estimated with a 95 % confidence interval (95 % CI). A p-value less than 0.05 was considered significant.

## **Results**

One hundred and seven HCWs (mean age  $31.8 \pm 9.3$  years, ratio women/men = 1.5) completed the questionnaire. The respondents were composed of 66 physicians (62%) and 41 members of the paramedical staff (38%). Paramedical staff members were older than those of medical staff: paramedics' age was  $36.1 \pm 8.9$  years vs.  $29.2 \pm 8.6$  ( $p < 0.001$ ). Forty four physicians were juniors -ie: residents and medical students- (67%) and 22 were seniors (33%). The member of nursing staff was broken as follows: nurses (30) and nurse's aids (11).

Main participants' characteristics are reported in Table 1.

One hundred and twenty two estimations (representing 2.5% of total estimations) were not provided by HCWs who felt unable to estimate even grossly the price of certain devices. Four thousand five hundred and eighty six were finally gathered,

The correct estimation rate according to the device is reported in Table 2. Overall, the number of estimated prices between 90 and 110% of the real prices was marginal, representing only 6.1% of all answers. In addition, the number of estimates defined as correct, ranging from 50% to 150% of the device's price, represented only 29% of total answers. The dialysis catheter was the most accurately estimated material with 54.3% of correct estimations, while the pleural drain was the most poorly evaluated, whose price was well estimated in only 7.5% of cases.

In univariate analysis, estimation's accuracy rate was different within the study population (Table 1). Percentage of correct estimation was significantly higher among paramedical staff compared to medical staff: 33.1% vs 26.2% ( $p = 0.025$ ). Among physicians, medical students had the lowest rate of acceptable estimations: they provided only 17.9% of correct estimations vs. 32.6% for seniors ( $p = 0.0001$ ). There was no difference between residents and seniors. In addition, the rate of correct estimation was higher among participants over 30 years of age. In this population, percentage of correct estimation was 34.6% ( $\pm 12.4$ ) vs. 18.4% ( $\pm 10.4$ ) in the  $\leq 30$  years group, ( $p < 0.0001$ ). There was no difference between men and women.

Second, the prices of the least cheap devices were most of the time overvalued, whereas the prices of the most expensive ones were undervalued (Figure 1). For example, devices costing less than 50 euros were overestimated by more than 75.6% of the respondents and underestimated in only 4.1% of cases, whereas  $> 5000$  euros devices prices -were overestimated by only 13.1% of the respondents and underestimated in 55.7% of cases.

The mean estimated price for devices below 50 euros was 450% [270-750] ( $p < 0.0001$ ) of the real price. On the other hand, the most expensive devices were largely undervalued: Above 500 euros, devices estimations were undervalued: -60% for 500-5000€ (-30; -70,  $p < 0.0001$ ), -60% for 5 000-500 000€ (-40; -70,  $p < 0.001$ ) and -60% (-10; -90,  $p < 0.0001$ ) for devices price over 500 000€ (Figure 2).

In multivariate analysis (Table3), four parameters were associated with an incorrect estimation: the device's price  $< 50$  euros [OR= 3.2; 95% CI( 1.6-6.3);  $p < 0.0001$ ], being a medical student [OR=2; 95% CI,(1.3-3),  $p = 0.006$ ], having an experience in hospital less than 10 years [OR=1.5; 95% CI(1.1-2.1),  $p = 0.02$ ] and working in an university affiliated hospital [OR 0.6 IC95%(0.4-0.9)].

Thus, the most favorable situation to get a correct estimate was a senior physician, working for more than 10 years in a non-university hospital, having to estimate the price of a device costing between 50 and 500 euros. Conversely, the most unfavorable situation to get an incorrect estimate was a medical student having to estimate the price of a device costing less than 50 euros.

## Discussion

Our study highlights the poor knowledge of ICU HCWs about the price of devices they daily use directly or indirectly for ICU patients' care. Even with a high margin error of 50%, barely one third of estimates were correct. Other studies assessing the awareness of HCWs regarding price of drugs showed similar results. Hernu *et al.* studied the cost-awareness of French physicians of their prescriptions' cost, and found that only a third of the estimates were within 50% of the real cost (12). This gap in cost's knowledge is not limited to ICU's HCWs and has also been reported among surgeons (14, 15), anesthesiologists (16), emergency physicians (11) and interventional radiologists (17) across different European countries.

Juniors, and especially medical students were the least aware of the cost of these devices, providing a correct estimation in only 18% of cases. On the opposite, length of service >10 years was associated with improved price estimations. Hernu *et al.* showed the same tendency (12), confirming that economic considerations are left aside during medical training, and that cost awareness is rising up with hospital practice. However, other studies did not find any difference between juniors and seniors (18).

We also observed that the price of the cheapest devices was overvalued whereas the price of the most expensive ones was underestimated. This observation has widely been reported in previous studies (19–21).

Senior physicians working in a non-university affiliated hospital estimated more accurately the price of the tested devices. This was also reported in other studies (12). It could be explained by a greater implication of physician in the management of the ICU budget in non-university affiliated hospital in facilities of limited size compared to university affiliated hospitals.

Last, the devices which cost was < 50 euros were more poorly evaluated than more expensive devices in multivariate analysis. This could be explained by the fact that as the true cost of items increases, the acceptable percent margin of error made the margin of error larger. For example, in our study, using  $\pm 50\%$  as the acceptable margin of error, a HCW estimation would have to be within 2€ (2 to 6€) of an item costing 4 euros compared with 10 000 € for an item costing 20 000€ (10 000 to 30 000€).

This study is the first to examine precisely the price of a broad range of devices rather than drugs or exams prescriptions' costs and discloses a poor knowledge in this field. All

categories of HCWs are represented, in the medical and paramedical staff, and only a few numbers of estimations were missing (2.5%). This poor awareness of physicians' of the cost of the devices they use is paradoxical considering that they determine or influence 60% of health care cost (22). We deeply think that it is physicians' responsibility to evaluate the budget wisely and this requires first of all a minimal knowledge of the cost of the equipment. Moreover, improving physicians' and nurses' knowledge of the cost of devices could help reducing the waste of disposable devices. In addition to that, a better cost awareness of expensive devices could increase their lifespan through a more careful use and a strict following of maintenance procedures. To improve this very specific skill that is cost awareness, concept of medical economics should be incorporated into medical and paramedical training, in order to acquire both an economical and a medical vision of patient care. Nevertheless, this strategy would be valuable only if HCWs are really implicated in budget analysis and expenditures evaluation

One limitation of our study is that HCWs were asked to estimate the price of a precise device. Considering the different devices used in the different ICUs, the price might have been different. To try to correct for that, we proposed in these situations to assess the price of equivalent devices (devices with similar level of performance) and to assess the estimated prices expressed as percentage of the real cost. Doing that allowed us to compare estimates prices of similar devices despite different prices. However, when the prices of devices with similar performance were considered as to discrepant (prices more or less than 50% of the prices in the reference center), these data were not included in the analysis. Doing that could have induced a limited bias, however, it could not explain to our opinion, such a low rate of correct estimations with this high margin of error.

## **Conclusion**

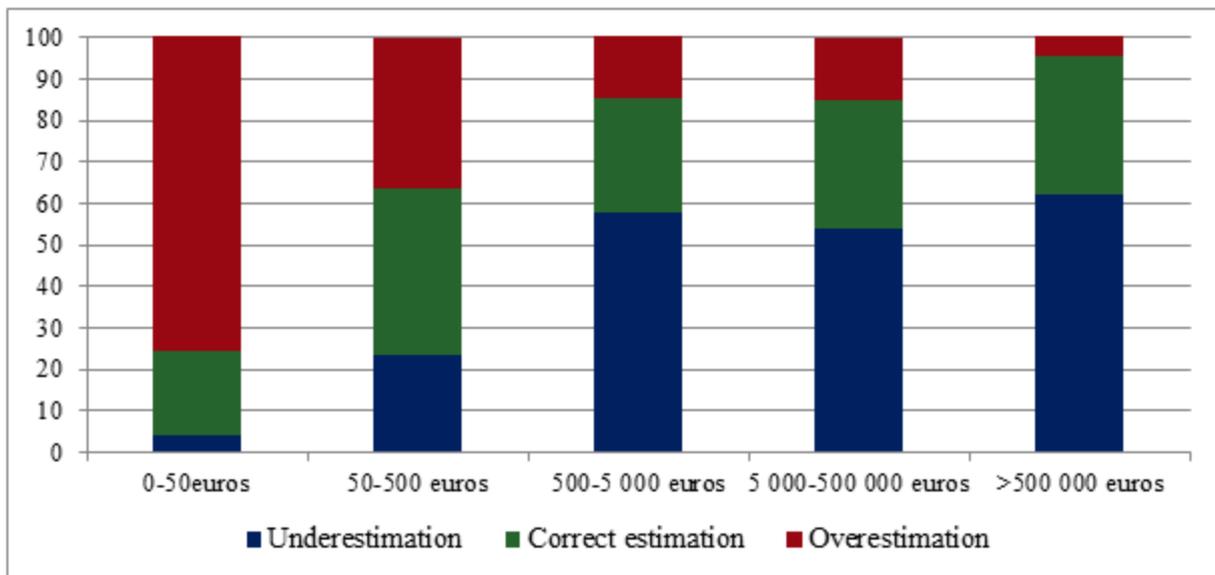
In this multicenter survey in which the prices of devices daily used for ICU patients care were asked to HCWs, only 29% of estimations were correct, considering a correct evaluation as an estimated price between 50 and 150% of the real price. Length of service , function, price of devices and type of facility were independently associated with correct cost estimation. The costs of the least expensive equipments were overvalued, while the costs of the most expensive devices were notoriously under estimated.

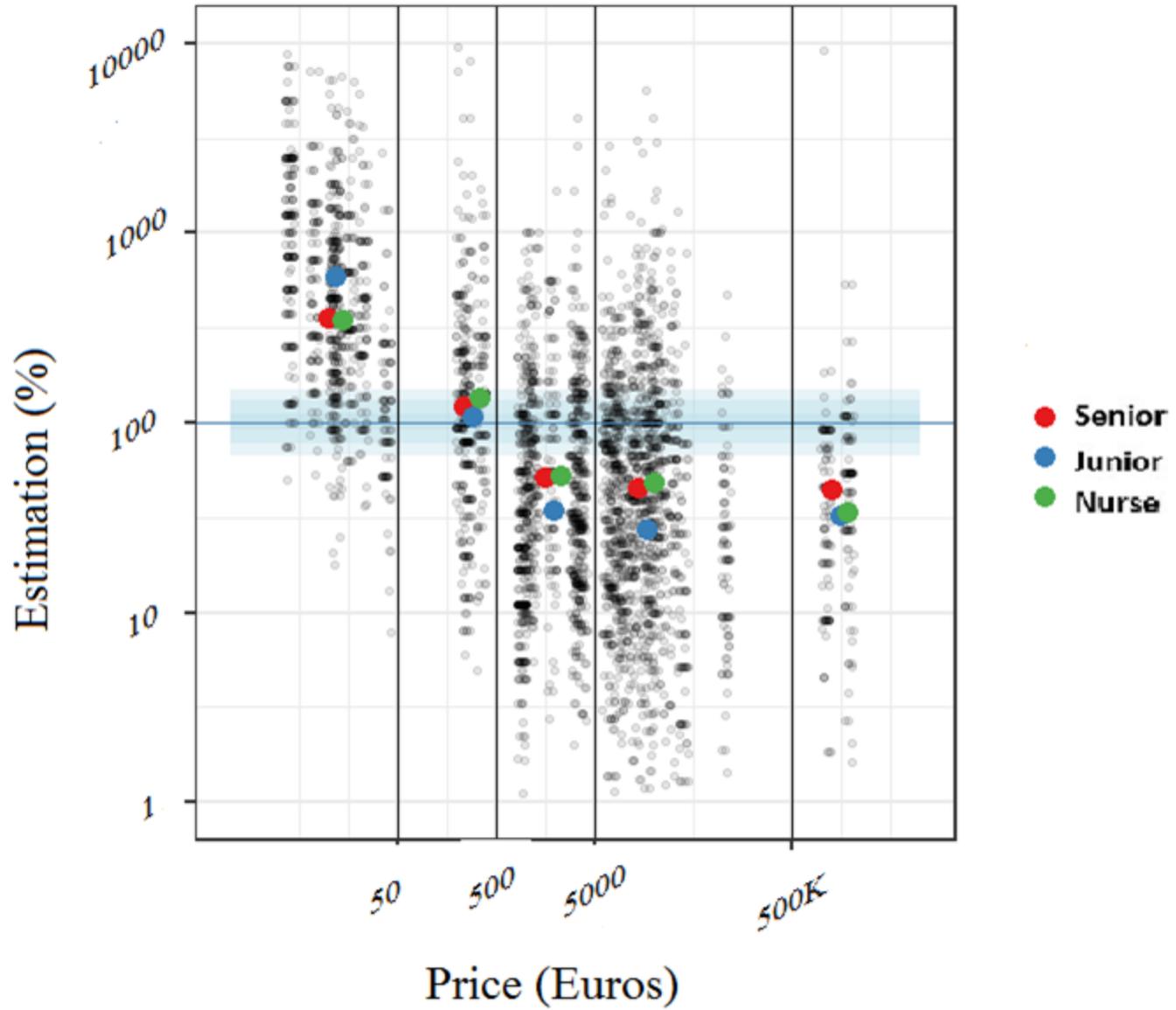
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**Figure 1:** Distribution of underestimation, correct estimation and overestimation according to the price of device. An underestimation was defined as below 50% of the true price, overestimation as over 150% of the true price, and a correct estimation as between 50 and 150% of the true price.

**Figure 2:** Price estimation's according to real cost and Health Care Worker's function. This is a logarithmic diagram with real prices on the x axis and estimated price (expressed in percentage of the real price) on the y axis. Junior corresponds to junior physician (resident) or medical student.





	Correct estimation (%)	Incorrect estimation n (%)	p-value
HCWs' characteristics			
<b>Medical staff (n=66)</b>	<b>741 (26.2)</b>	<b>2089 (73.8)</b>	0.0025 <sup>a</sup>
Senior physician (n=22)	295 (32.6)	609 (67.4)	
Junior physician (n=24)	307 (28)	791 (72)	0.0001 <sup>b</sup>
Medical student (n=20)	164 (17.9)	752 (82.1)	
<b>Paramedical staff (n=41)</b>	<b>581 (33.1)</b>	<b>1175 (66.9)</b>	
Nurse (n=30)	427 (33.1)	861 (66.9)	
Nurse's aid (n=11)	154 (32.8)	314 (67.1)	
Total (n=107)	<b>1322 (28.8)</b>	<b>3264 (71.2)</b>	
<b>Age</b>			
< 30 years (n=56)	589 (24)	1867 (76)	<0.0001
>30 years (n=48)	695 (34.8)	1305 (65.2)	
Not reported (n=3)	-	-	
<b>Sex</b>			
Male (n=44)	550 (29.3)	1330 (70.7)	0.905
Female (n=59)	729 (28.8)	1801 (71.2)	
Not reported (n=4)	-	-	

**Table 1.** Prices estimation accuracy according to Health Care Workers' characteristics. Results are expressed as number and percentage of correct and incorrect estimations. Correct estimation was defined as an estimated price between 50% and 150% of the real price. <sup>a</sup>: comparison between medical and paramedical staff. <sup>b</sup>: comparison between senior physicians and medical students

Devices	Real price (€)	±10%	±25%	±50%
<b>&lt;50 €</b>				
Metal laryngoscope blade	4	2 (1.9)	12 (11.2)	14 (13.1)
Chest tube	4	2 (2.2)	7 (7.5)	7 (7.5)
Radial artery catheter (8 cm)	7	4 (3.7)	7 (6.5)	18 (16.8)
2-lumens catheter (30 cm)	11	9 (8.4)	10 (9.3)	21 (19.6)
Supra-pubic catheter	11	10 (9.3)	11 (10.3)	15 (14)
3-lumens catheter (16 cm)	12	2 (1.9)	15 (14)	23 (21.5)
Arterial catheter pressure sensor	16	4 (4.3)	10 (10.8)	15 (16.1)
Pleural drainage kit	22	11 (10.3)	14 (13.1)	21 (19.6)
Dialysis catheter (20 cm)	38	11 (10.3)	25 (27.2)	50 (54.3)
<b>50-500 €</b>				
Plasmapheresis kit	212	17 (16)	21 (19.8)	37 (34.9)
Single use bronchoscope	250	11 (10.3)	38 (35.5)	52 (48.6)
Fecal management system	250	11 (10.3)	33 (30.8)	40 (37.4)
Enteral nutrition pump	350	1 (0.9)	14 (13.1)	44 (41.1)
<b>500-5 000 €</b>				
Hygiene dedicated trolley	900	0 (0)	4 (4.4)	8 (8.9)
Electric smart pump	900	1 (0.9)	28 (26.2)	37 (34.6)
Roll board	900	0 (0)	3 (2.8)	13 (12.1)
Light source fibroscope	1 000	14 (13.1)	23 (21.5)	37 (34.6)
Volumetric pump	1 100	9 (8.5)	11 (10.4)	30 (28.3)
Emergency trolley	1 200	3 (2.8)	25 (23.4)	36 (33.6)
Video laryngoscope	1 800	2 (1.9)	22 (20.6)	41 (38.3)
Echocardiography probe	3 000	7 (7.5)	8 (8.6)	27 (29)
Rolling stretcher	3 200	5 (4.7)	8 (7.5)	23 (21.5)
Transport patient monitor	3 400	0 (0)	16 (15)	28 (26.2)
Measurement module monitor	3 500	4 (3.7)	14 (13.1)	37 (34.6)
Electrocardiogram	3 700	4 (3.7)	10 (9.3)	28 (26.2)
<b>5 000-500 000 €</b>				
Mobile defibrillator	6 500	4 (3.8)	28 (26.4)	33 (31.1)
Pocket ultrasound	7 000	18 (19.4)	26 (28)	58 (62.4)
Patient mobile lift	7 300	2 (1.9)	5 (4.7)	17 (15.9)
Reusable bronchic fibroscope	8 300	9 (8.4)	26 (24.3)	45 (42.1)
Patient monitoring screen	8 800	4 (3.7)	15 (14)	30 (28)
Central monitoring station	9 800	8 (7.5)	10 (9.3)	23 (21.5)
Transport ventilator	12 000	3 (2.8)	11 (10.3)	28 (26.2)
Point of care blood gases analyzer	13 000	4 (3.7)	23 (21.5)	27 (25.2)
Intra Unit medicine cabinet	15 000	8 (7.5)	11 (10.3)	29 (27.1)
Transoesophageal probe	17 000	2 (1.9)	8 (7.5)	15 (14)
Intensive care bed	18 000	7 (6.5)	29 (27.1)	46 (43)
Plasmapheresis generator	20 000	9 (8.5)	22 (20.8)	42 (39.6)
Hand held echography unit	20 000	10 (10.8)	16 (17.2)	34 (36.6)
ICU mechanical ventilator	24 000	2 (1.9)	28 (26.2)	40 (37.4)
Dialysis unit	31 000	8 (7.5)	19 (17.9)	33 (31.1)
Endoscope washer	38 700	0 (0)	6 (6.5)	13 (14)
Echocardiography unit	105 000	4 (3.7)	6 (5.6)	19 (17.8)
<b>&gt;500 000 euros</b>				
CT Scan machine	1 090 000	20 (18.9)	23 (21.7)	36 (34)
MRI machine	1 848 240	13 (12.1)	22 (20.6)	52 (48.6)
Global correct estimation %		6.1	15.8	28.8

**Table 2.** Distribution (n) and percentages of estimated costs of devices investigated in the study. The number and percentages (according to the number of answers given by HCWs) of estimated prices were computed for values ranging between ± 10%, ± 25% or ± 50% of the real price. Some equivalent absolute values (number of estimated prices) could correspond to different percentages because all the 107 respondents did not provide answers for the totality of devices.

Factors associated with an incorrect estimation	Odd ratio [95%CI]	p-value
<b>Price (euros)</b> <50 50-500 500-5 000 5 000-500 000 >500 000	3,2 [1,6 – 6,3] 1 (ref) 2,0 [1,1 – 3,9] 1,9 [1 – 3,4] 0,9 [0,4 – 2,5]	<0,0001
<b>Grade</b> Senior Junior Medical student Nurse Care-giver	1 (ref) 1,2 [0,9 – 1,9] 2,0 [1,3 – 3,0] 1,1 [0,8 – 1,6] 1,3 [0,8 – 2,1]	0,006
<b>Seniority</b> <10 years ≥ 10 years	1,5 [1,1 – 2,1] 1 (ref)	0,02
<b>Facility level (for seniors)</b> Academic Non-academic	1 (ref) 0,6 [0,4-0,9]	0,02

**Table 2.** Multivariate analysis of factors associated with an incorrect estimation.