Intensive Care Med (2015) 41:1454–1456
DOI 10.1007/s00134-015-3911-1

EDITORIAL

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Do you know how much it costs?

Received: 27 May 2015
Accepted: 3 June 2015
Published online: 23 June 2015

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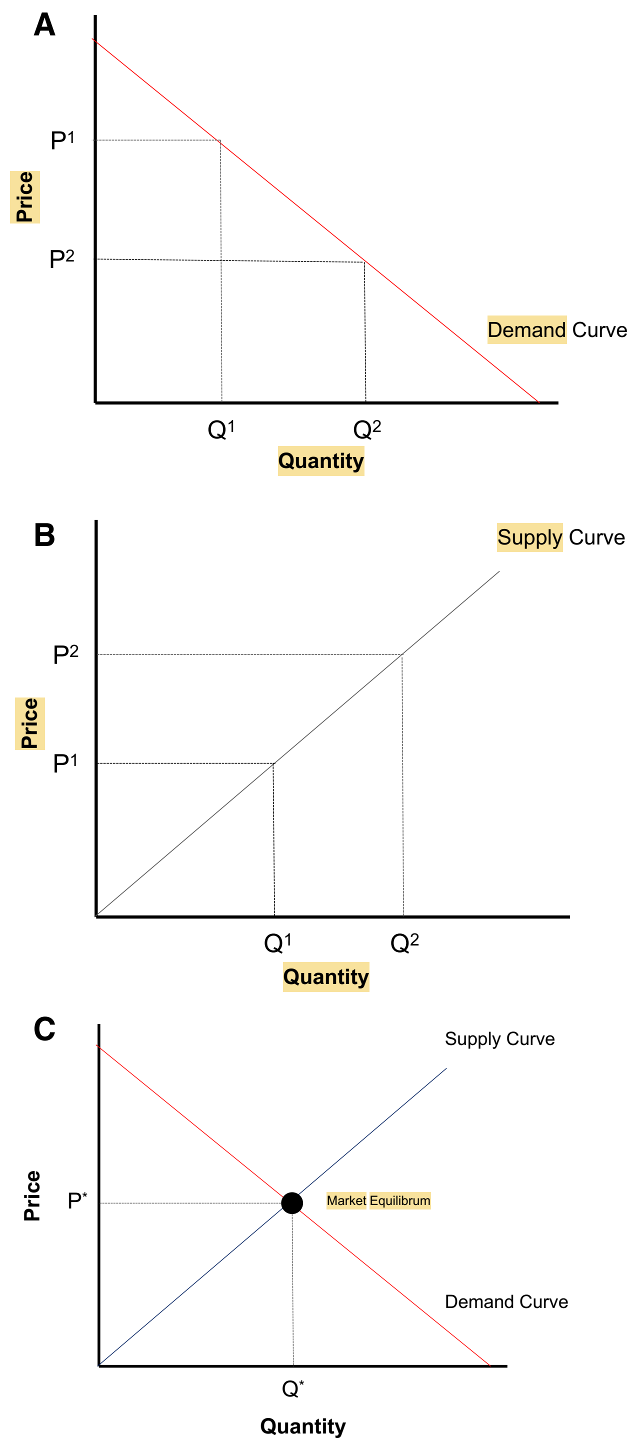
Economics, as a scientific discipline, deals with the production, distribution, and consumption of goods and services and is chiefly concerned with the allocation of scarce resources. From an economics standpoint, if something is scarce, it will have market value. There are two laws that every student of economics learns in the first week of the first class during the first year of their education. The first law, known very simply as the law of supply, states that, all other factors being equal, as the price of a good or service increases, the quantity of that good or service offered or sold by the suppliers of that good or service will increase. The second law (known as the law of demand) is just as elegant and states that, all other factors being equal, as the price of a good or service increases, consumer demand for that good or service will decrease. Importantly, in a perfectly competitive market, the equilibrium price of a good or service occurs at the point at which the quantity demanded and quantity supplied are equal (i.e., at the point at which the downward-sloping demand curve and the upward-sloping supply curve intersect each other, see Fig. 1). In other words, if the supply of a good or service is low, the market price will rise, as long as there is sufficient demand from consumers. If there is excess supply of a good or service, the market price will fall. In a similar way, as long as there is sufficient supply of a good or service, if consumer demand for that good or service is low, the market price will fall. Conversely, if the demand of the good or service increases, the market price will rise.

Many economists would argue that the best way to allocate a scarce resource is to rely upon free market principles. A perfectly competitive market is defined as a market where prices are determined entirely by the laws of supply and demand, with little or no government control. There are three fundamental criteria that are necessary for perfect competition:

1. There are no barriers to entry or exit for buyers and sellers.
2. There are many buyers and sellers in the market, so that no single buyer or seller has the market power to set the price of a good or service on his or her own.
3. Every buyer and every seller has the same information that he or she can use to make rational decisions.

The necessary conditions for perfect competition do not exist in health care today, even in the USA. For example, the entry of new providers and hospitals are limited by licensure requirements, board certification, and certificate of need (CON) laws [1]. At least in the USA, there have been a growing number of hospital mergers and acquisitions and a trend for greater vertical and horizontal integration [2]. Collectively, consolidation and integration reduces the number of suppliers of health care services, creating conditions less favorable to perfect competition. Finally, and perhaps most important is the issue of information asymmetry. Health care providers generally know much more about providing care than patients. Neither the quality nor the price of health care services is readily available to the average patient as consumer. On the flip side, patients may not fully disclose information about their condition to either the insurance provider or health care provider [3].



◀**Fig. 1** **a** The demand curve is always downward sloping. By convention, price is always on the *y* axis and quantity is always on the *x* axis. In a perfectly competitive market, assuming everything else is constant, as the price decreases from P^1 to P^2, the quantity of the good or service demanded by the consumer increases from Q^1 to Q^2. **b** The supply curve is upward sloping. In a perfectly competitive market, assuming everything else is constant, as the price increases from P^1 to P^2, the quantity of a good or service produced by the supplier increases from Q^1 to Q^2. **c** The supply curve and demand curves intersect at the equilibrium price. In a perfectly competitive market, as long as supply and demand remain constant (i.e., neither the supply curve or demand curve shift in position or slope), the quantity of a good or service that is demanded by the consumer will equal the quantity supplied by the supplier at Q^*, which also occurs at price = P^*

The lack of quality and price transparency in health care is a pervasive problem, even in countries with universal access and coverage. Several studies have shown that physicians are generally unaware of the cost of nearly all of the care that they provide [4, 5]. Physicians are directly or indirectly responsible for nearly all of the care that is delivered. The theory is that if physicians fully appreciated the costs of the services and treatments that they provide, the rising health care costs could be better controlled. Moreover, greater awareness of the costs of care could be one way of leveraging free market principles to lower costs, according to the laws of supply and demand discussed above [6, 7].

There is great interest in reducing the cost of care in the intensive care unit (ICU) setting [8–10]. ICU care accounts for a significant proportion of total health care costs [11], accounting for between 17.4 and 39.0 % of all hospital costs in some studies [11–14]. Reducing ICU costs will therefore have a significant impact on the health care costs as a whole. As mentioned above, one potential strategy for reducing the costs of care in the ICU is through increasing physicians' awareness of these costs. Most of the aforementioned studies on physicians' awareness of health care costs have been performed outside the ICU setting.

With this in mind, Hernu and colleagues [15], in a recently published article, surveyed over 1300 physicians working in 99 French ICUs with a response rate of 83 %. The survey questionnaire asked physicians to estimate the cost of 46 different treatments in one of four treatment groups (drugs, blood products and derivatives, imaging modalities, and laboratory tests). The survey also included two clinical scenarios, septic shock due to community-acquired pneumonia and hemorrhagic shock occurring under vitamin K antagonist treatment. Physicians were asked to estimate the cost of all treatment for a 7-day ICU stay for these two conditions. Only 315/1092 (29 %) of the physicians' estimates were within 50 % of the true cost, as determined by the French national average costs. Drug costs were the most significantly underestimated costs, and only imaging modality costs were routinely overestimated. Most physicians tended to overestimate the cost of relatively inexpensive medications and significantly underestimate the cost of expensive medications. These trends persisted when physicians were asked to estimate the cost of care in the two clinical scenarios. Younger physicians were more likely to incorrectly estimate the cost of care compared to older physicians. Somewhat surprisingly, female physicians were also more likely to incorrectly estimate the cost of care compared to male physicians.

Increasing cost awareness may turn out to be an important strategy to reducing the cost of care in the ICU setting. Greater cost transparency will certainly help alleviate some of the information asymmetry that exists in health care today. The study by Hernu and colleagues [15] provides important background information with which we may begin to tackle this issue. While the fact that older physicians more accurately estimate costs compared to younger physicians is intuitive (with age comes experience!), the reasons for why there is a gender difference in how accurate physicians are in estimating costs deserves further study. Clearly, we need to do a better job of educating physicians on how their decisions impact the overall cost of care. Do you know how much care in your ICU costs? Maybe it is time to find out.

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Intensive Care Med (2015) 41:1402–1410
DOI 10.1007/s00134-015-3859-1

ORIGINAL

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Cost awareness of physicians in intensive care units: a multicentric national study

Received: 16 January 2015
Accepted: 1 May 2015
Published online: 22 May 2015

On behalf of the "Costs in French ICU" Study Group.

The list of co-investigators appears in the "Appendix" section.

Take-home message: ICU physicians have a poor awareness of prescriptions costs, especially with regards to high-cost drugs. Considerable emphasis and effort are still required to integrate the cost-containment problem into the daily prescriptions in ICUs.

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Abstract *Purpose:* Physicians play an important role in strategies to control health care spending. Being aware of the cost of prescriptions is surely the first step to incorporating cost-consciousness into medical practice. The aim of this study was to evaluate current intensivists' knowledge of the costs of common prescriptions and to identify factors influencing the accuracy of cost estimations. *Methods:* Junior and senior physicians in 99 French intensive care units were asked, by questionnaire, to estimate the true hospital costs of 46 selected prescriptions commonly used in critical care practice. *Results:* With an 83 % response rate, 1092 questionnaires were examined, completed by 575 (53 %) and 517 (47 %) junior and senior intensivists, respectively. Only 315 (29 %) of the overall estimates were within 50 % of the true cost. Response errors included a 14,756 ± 301 € underestimation, i.e., −58 ± 1 % of the total sum (25,595 €). High-cost drugs (>1000 €) were significantly ($p < 0.001$) the most underestimated prescriptions (−67 ± 1 %). Junior grade physicians underestimated more costs than senior physicians ($p < 0.001$). Using multivariate analysis, junior physicians [odds ratio (OR), 2.1; 95 % confidence interval (95 % CI), 1.43–3.08; $p = 0.0002$] and female gender (OR, 1.4; 95 % CI, 1.04–1.89; $p = 0.02$) were both independently associated with incorrect cost estimations. *Conclusions:* ICU physicians have a poor awareness of prescriptions costs, especially with regards to high-cost drugs. Considerable emphasis and effort are still required to integrate the cost-containment problem into the daily prescriptions in ICUs.

Keywords Cost awareness · Health care cost control · Drugs · Quality improvement

Introduction

In many Western countries, the economic imbalance of public health systems is directly linked to the uninterrupted increase in health care expenses [1]. Clinicians, responsible for the consumption of nearly all of the care and medical goods, play an important role in strategies for directing health care spending [2–4].

Previous studies have shown important cost savings through the application of rationalized prescriptions while maintaining equivalent heath care management [5–11]. In any health system, a medical cost-control strategy involves the optimization of health expenses through the promotion of medical care quality and the application of established care practices. In France, for example, replacing a global endowment health management system with an activity-based financing system rapidly compelled physicians to accept greater accountability in the cost-control problem [12]. Medical prescriptions are therefore meant to be more considered and more reasonable. More and more doctors feel that costs are an important consideration in the medical thought process that leads to prescribing decisions [13, 14].

Nowadays, incorporating cost-consciousness into our daily practice is unavoidable. Intensive care units (ICUs) represent a large portion of health care expenditures, estimated to reach up to 20 % of some hospital budgets [15]. Consequently, reducing costs in these units has become a priority [16]. Changing physicians' attitudes towards cost control requires preliminary knowledge of prescription costs. Previous surveys, conducted in North America and Europe, have shown that doctors have a poor understanding of the costs of drugs, laboratory tests, and imaging modalities [17–23]. While several studies were aimed at optimizing ICU prescription strategies, only a few small studies performed over ten years ago investigated intensivists' cost awareness [17, 19, 20].

The aim of the present work was to assess current intensivists' knowledge of prescriptions costs in a national ICU study and to identify factors influencing the accuracy of cost estimations.

Materials and methods

Study design

A written questionnaire study was performed from May to December 2010. In each participating unit, every junior (residents and medical students) and senior (MD degree) intensive care physician was surveyed by a local correspondent. The characteristics of the participants (age, sex, level of training, financial training) and descriptions of the centers (medical/surgical ICU, academic/nonacademic hospital) were collected. Surveyed prescribers were anonymously asked to individually estimate the true costs of selected prescriptions.

Questionnaire

The questionnaire listed 46 prescriptions (medications and investigations) commonly used for diagnosis and treatment in ICU practice. These were gathered into four groups: drugs, blood products and derivatives, imaging modalities, and laboratory tests (Table 1). For each group, items were distributed in homogenous subgroups defined a priori (Table 1). The selected prescriptions were either the most frequent and/or expensive ones (annual amount) or regarded as essential to ICU practice. The total cost of the prescriptions was 25,595 €. True hospital costs were obtained using the average costs of drugs and blood products and derivatives in the Hospices Civils de Lyon (i.e., the University Teaching Hospital of Lyon, France), while the costs of the imaging modalities and laboratory tests were based on the French national averages. By the end of the study, a questionnaire with correct estimates was sent to each participant.

Typical clinical cases

To appreciate the value of cost awareness in the real world, we took into account two clinical situations observed daily in ICU practice: (1) septic shock due to community-acquired pneumonia (case 1); (2) hemorrhagic shock occurring under vitamin K antagonist (case 2). As reported in Table 1, we considered a 7-day ICU management associated with a number of prescriptions. The true costs, amounting in total to 2223 € for case 1 and 7238 € for case 2, were compared to estimated costs.

Statistical analysis

Data were expressed as number (percentage) and as mean ± standard error of the mean (SEM), as appropriate. The data analysis was performed as follows: calculation of response rates, description of physicians' characteristics, evaluation of the accuracy of the estimates within margins of error defined a priori (±10, ±25, ±50, and >50 %), comparison of estimate deviations (in real and absolute values), and identification of factors influencing cost estimation accuracy. Accuracy was defined by estimates within 50 % of the true cost.

Univariate comparisons were performed using an analysis of variance (ANOVA) for continuous variables, and a Chi-squared test for categorical variables, as appropriate. The independent contribution of physicians' characteristics to incorrect estimations was tested by a logistic regression analysis. All variables with a p value less than 0.10 following univariate analysis were introduced into the model. Odds ratios (OR) were estimated with a 95 % confidence interval (95 % CI). Statistical analysis was performed using MedCalc® 7.4.3.0 software (Medcalc, Mariakerke, Belgium). A p value of less than 0.05 was considered as significant.

Table 1 True costs, estimated costs, and typical clinical cases

	Cost (€)	Estimate (€)[c]	Case 1[d]	Case 2[d]
Drugs				
Less than 10 €				
Enoxaparin 0.4 ml SC[a]	0.4	9.7 ± 0.6	5	0
Sodium chloride 0.9 % 500 ml IV[a]	0.6	3.4 ± 0.2	12	4
Omeprazole 40 mg IV[a]	0.6	10 ± 1	0	7
Ceftriaxone 2 g IV[a]	1.2	15 ± 1	7	0
Paracetamol 1 g IV	1.5	8.6 ± 1.1	4	4
10–100 €				
Hydroxyethyl starch 500 ml IV[a]	10	15 ± 1	0	6
Norepinephrine 48 mg IV[b]	18	33 ± 2	3	2
Parenteral nutrition 1970 ml IV[b]	36	48 ± 2	2	2
Piperacillin-tazobactam 12 g IV[b]	37	64 ± 3	0	0
Levofloxacin 1 g IV[b]	43	58 ± 3	7	0
100–1000 €				
Propofol 5 g IV[b]	116	71 ± 3	5	4
Cisatracrium 450 mg IV[b]	122	61 ± 3	2	1
Linezolid 1200 mg IV[b]	127	145 ± 8	0	0
Fosphenytoin 1.5 g IV[a]	181	28 ± 1	0	0
Caspofungin 50 mg IV[a]	489	207 ± 12	0	0
More than 1000 €				
Human immunoglobulin 30 g IV[b]	1195	545 ± 27	0	0
Tenecteplase 10,000 UI IV[a]	1337	325 ± 23	0	0
Nitric oxide 20 l Inh	1812	538 ± 33	0	0
Digoxin immun Fab 380 mg IV[a]	2374	742 ± 64	0	0
Drotrecogin alfa 180 mg IV[a]	8640	2976 ± 140	0	0
Blood products and derivatives				
Plasma				
Fresh frozen plasma IV (1 unit)	97	166 ± 6	0	4
Red cells				
Red cells concentrate IV (1 unit)	195	135 ± 4	0	10
Platelets				
Platelet concentrate IV (1 unit)	450	238 ± 10	0	2
Blood derivatives				
Human albumin 20 % 100 ml IV[a]	39	143 ± 9	0	0
Human fibrinogen concentrate 1.5 g IV[a]	748	232 ± 9	0	2
Prothrombin complex concentrate 750 UI IV[a]	878	380 ± 22	0	1
Recombinant activated factor VII 7 mg IV[a]	4574	1723 ± 23	0	0
Imaging modalities				
Basic radiology				
Plain abdominal X-ray	38	34 ± 1	0	0
Chest X-ray	44	32 ± 1	6	3
Echo-Doppler				
Leg Doppler ultrasound	73	82 ± 2	0	0
Abdominal ultrasound	79	64 ± 2	0	1
CT/MRI				
Brain MRI	176	364 ± 9	0	0
Thoracic-abdominal-pelvic CT	184	324 ± 11	0	0
Specialized radiology				
Abdomino-pelvic arteriography-embolization	789	1723 ± 122	0	0
Laboratory tests				
Hematology				
Blood count	9.4	13 ± 0.4	5	10
Coagulation factors	9.4	16 ± 0.5	3	6
ABO group and rhesus typing	16	27 ± 1	1	1
Biochemistry				
Troponin Ic	18	16 ± 1	2	2
Ionogram	20	18 ± 1	8	6
Arterial blood gas and lacticemia	31	16 ± 1	10	8
Toxicology				
Ethanol blood level	13	11 ± 0.3	0	1
Standard toxicology screen	81	46 ± 2	0	0
Toxicological HPLC screening	127	70 ± 3	0	0
Microbiology				
Blood culture	23	29 ± 1	3	1
Universal bacterial PCR	100	104 ± 4	0	0
CSF analysis	240	74 ± 2	0	0

SC subcutaneous, *IV* intravenous, *Inh* inhaled, *CT* computed tomography, *MRI* magnetic resonance imaging, *HPLC* high-performance liquid chromatography, *PCR* polymerase chain reaction, *CSF* cerebrospinal fluid, *Case 1* case of septic shock due to community-acquired pneumonia, *Case 2* case of hemorrhagic shock under vitamin K antagonist

[a] One injection cost
[b] Daily injection cost
[c] Results expressed as mean ± SEM
[d] Number of items

Results

The response rate among the physicians of the 99 participating services was 83 %: 1092 questionnaires were completed from the 1315 surveys handed out. There was no significant difference between the response rates from academic (83 ± 21 %) and nonacademic (84 ± 21 %) hospitals (p = ns).

The characteristics of the respondents are summarized in Table 2. The majority of physicians were under 40 years old (79 %), male (sex ratio 1.5), and operating in medical or medical and surgical ICUs (83 %). As expected, the ratio junior/senior physicians was significantly higher ($p < 0.01$) in academic hospitals (3.7) when compared to nonacademic hospitals (0.3).

Concerning cost accuracy, most estimates were not within 50 % of the true cost for any prescription group (Table 3). Only 315 physicians (29 %) accurately estimated costs within 50 % of the true cost for the total amount (25,595 €). Response errors included an underestimation of 14,756 ± 301 €, i.e., −58 ± 1 % of the total sum. Absolute value deviations were 79 ± 1 % for drugs, 81 ± 2 % for blood products and derivatives, 73 ± 2 % for imaging modalities, and 73 ± 1 % for laboratory tests. As shown in Fig. 1a, drug costs were the most significantly ($p < 0.001$) underestimated (−64 ± 1 %), when compared to blood products and derivatives (−57 ± 2 %) or laboratory tests prescriptions (−36 ± 1 %). Imaging modality prescriptions were the only costs that were overestimated (7 ± 3 %). As shown in Fig. 1b, most prescription subgroups were underestimated. A clear trend in the overestimation of cheap prescriptions and the underestimation of expensive ones was observed. This was particularly true in drugs estimations (Table 4). For example, the drug subgroup "less than 10 €" was the only one commonly overestimated (961 ± 45 %). In contrast, "more than 1000 €" was the most underestimated drug subgroup (−67 ± 1 %), representing a considerable economic impact (−10,235 ± 196 € for a true cost of 15,358 € for this subgroup of prescriptions).

Meaningful underestimations were also found in the two considered clinical situations. Using a ±50 % margin of error, our analysis indicated that 393 physicians (36 %) inaccurately estimated costs of prescriptions for case 1 (septic shock), 513 (47 %) for case 2 (hemorrhagic shock). Response errors of physicians averaged −173 ± 46 €, i.e., −8 ± 2 % of the true cost, for case 1, and −2423 ± 102 €, i.e., −33 ± 1 %, for case 2.

For the underestimated groups of prescriptions and for the total amount, the cost estimations of senior grade physicians were more accurate ($p < 0.05$) than those of the juniors (Fig. 1a). Age, sex, level of experience, hospital characteristics, and financial training significantly influenced the accuracy of cost estimations (Table 2). In multivariate analysis, junior physicians (OR, 2.1; 95 % CI, 1.43–3.08; $p = 0.0002$) and female gender (OR, 1.4; 95 % CI, 1.04–1.89; $p = 0.02$) were the only variables independently associated with incorrect cost estimations.

Discussion

The present study shows that, on a national level, intensivists have poor awareness of ICU costs. This knowledge deficit, particularly apparent among junior

Table 2 Physician characteristics and factors influencing costs estimations

Characteristics	Total (n = 1092)	Correct estimation (n = 315)	Incorrect estimation (n = 777)	Univariate analysis p	Multivariate analysis OR (95 % CI)
Age (years)[a]	33 ± 1	36 ± 1	32 ± 1	<0.001	0.99 (0.97–1.01)
Sex[b]				<0.0001	–
Male	650 (60)	218 (69)	432 (56)	–	–
Female	442 (40)	97 (31)	345 (44)	–	1.40 (1.04–1.89)[c]
Level of training[b]				<0.0001	–
Junior	575 (53)	115 (37)	460 (59)	–	2.10 (1.43–3.08)[c]
Senior	517 (47)	200 (63)	317 (41)	–	–
ICU activity[b]				0.47	–
Medical	461 (42)	127 (40)	334 (43)	–	–
Surgical	183 (17)	47 (15)	136 (17)	–	–
Medical and surgical	448 (41)	141 (45)	307 (40)	–	–
Hospital[b]				<0.05	–
Academic	743 (68)	200 (63)	543 (70)	–	–
Nonacademic	349 (32)	115 (37)	234 (30)	–	1.07 (0.75–1.36)
Financial training[b]	17 (1.6)	6 (1.9)	11 (1.4)	0.01	1.03 (0.37–2.88)

OR odds ratio, *CI* confidence interval
[a] Results expressed as mean ± SEM
[b] Results expressed as number (%)
[c] $p < 0.05$

Table 3 Accuracy of costs estimations

	±10 %	±25 %	±50 %	>50 %
Drugs				
Less than 10 €	15 (1.4)	32 (2.9)	39 (3.6)	1053 (96)
10–100 €	110 (10)	287 (26)	555 (51)	537 (49)
100–1000 €	51 (4.7)	139 (13)	354 (32)	738 (68)
More than 1000 €	30 (2.7)	70 (6.4)	211 (19)	881 (81)
Total (16,541 €)	34 (3.1)	81 (7.4)	228 (21)	864 (79)
Blood products and derivatives				
Plasma	188 (17)	271 (25)	431 (39)	661 (61)
Red cells	113 (10)	123 (11)	529 (48)	563 (52)
Platelets	12 (1.1)	134 (12)	348 (32)	744 (68)
Blood derivatives	33 (3.0)	96 (8.8)	203 (19)	889 (81)
Total (6982 €)	44 (4.0)	112 (10)	220 (20)	872 (80)
Imaging modalities				
Basic radiology	105 (9.6)	253 (23)	519 (48)	573 (52)
Echo-Doppler	158 (14)	363 (33)	737 (67)	355 (33)
CT/MRI	91 (8.3)	340 (31)	533 (49)	559 (51)
Specialized radiology	59 (5.4)	126 (12)	500 (46)	592 (54)
Total (1384 €)	144 (13)	351 (32)	704 (64)	388 (36)
Laboratory tests				
Hematology	68 (6.2)	171 (16)	420 (38)	672 (62)
Biochemistry	81 (7.4)	240 (22)	486 (45)	606 (55)
Toxicology	94 (8.6)	241 (22)	547 (51)	545 (49)
Microbiology	80 (7.3)	166 (15)	379 (36)	713 (64)
Total (688 €)	84 (7.7)	230 (21)	521 (48)	571 (52)
Overall (25,595 €)	34 (3.1)	94 (8.6)	315 (29)	777 (71)

Results expressed as number (%)

CT/MRI computed tomography/magnetic resonance imaging

physicians, is dramatically illustrated in the lack of appreciation of the costs of the most expensive prescriptions.

The burden of the economic situation in health care demands the application of a medical cost-control strategy, urging physicians to provide cost-effective management without compromising quality of care. The goal of a tight cost-control management is obviously not to reduce the level of care but to optimize resources allocated for health, which are not unlimited. Respecting evidence-based medicine, physicians must now make choices when prescribing in order to give cost-effectiveness and optimal care quality [24, 25]. Because of the large portion of health care expenditure directly attributable to the ICUs, this urgent issue is particularly important in critical care medicine [26, 27]. Indeed, on a daily basis, intensivists are faced with new diagnostic tests, specialized disposables, or expensive drugs, which represent a significant part of the growing expenditures of health care [28, 29]. Individually, ICU prescribers play a key role in the critical care cost-containment problem: their medical responsibility is especially linked to the economic impact of the care they provide. Making prescribers responsible requires in-depth changes in prescribing patterns and in the physician's attitudes towards cost awareness [3, 13]. Being aware of prescription costs is surely the first step in incorporating cost-consciousness into medical prescribing decisions [30–32].

Here, we carried out the largest study to date concerning cost awareness among physicians. Previous studies were mainly conducted in North America and Europe in the 1990s and 2000s and evaluated drug cost awareness among general practitioners, emergency physicians, or anesthetists [17–23]. Inadequate knowledge of costs by physicians was consistently found in these surveys [17–23]. Despite the growing need of medical responsibilization in cost control, cost awareness has not apparently improved over time. As demonstrated by our results, cost accuracy remains largely insufficient, even if we choose a quite large margin of error (±50 %) to define "correct" estimations. We also found that estimations by senior grade physicians were more accurate than their junior colleagues. This result was in contrast with previous reports that showed that the level of experience had no influence on cost awareness [20–22]. This specific influencing factor has probably been identified in our study owing to the high number of responders. Impact of professional experience on cost-consciousness is encouraging, suggesting that physicians may gradually incorporate economic considerations into their medical practices. We also found that cost estimations by female intensivists were less accurate than those of men. To the best of our knowledge, physician gender influence has never previously been documented. Our results also show that physicians have a tendency to overestimate cheap prescriptions and to underestimate expensive ones, a point

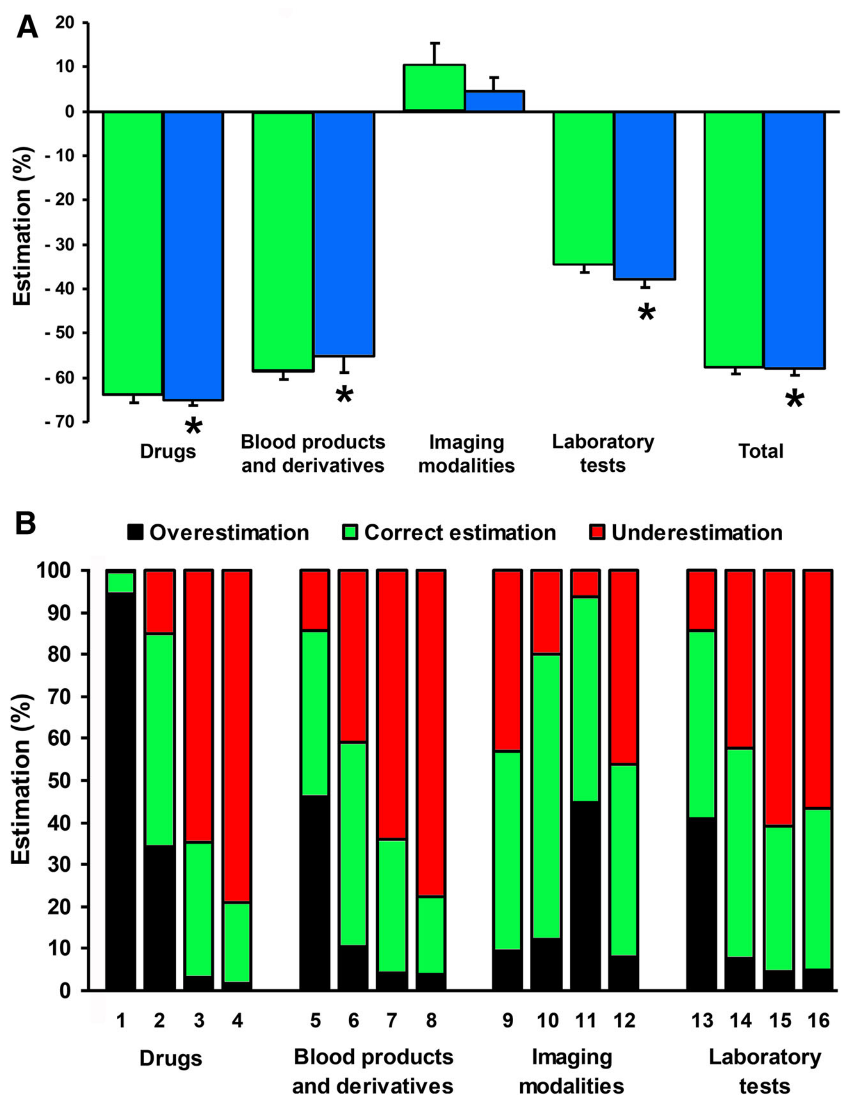

Fig. 1 **a** Cost estimations according to level of training of the physicians. For most of the underestimated groups of prescriptions and for the total amount, estimations by senior grade physicians (*green bar*) were significantly more accurate than those of junior physicians (*blue bar*). *$p < 0.05$ versus "seniors". **b** Cost estimations according to prescription subgroups. Correct estimations (*green bar*) were defined as being within 50 % of the true cost, overestimations (*black bar*) >50 % of the true cost, and underestimations (*red bar*) <−50 % of the true cost. The "<10 €" drugs subgroup (i.e., the cheapest one) was the only subgroup overestimated by more than 50 % of responders. The more expensive the other subgroups were, the more underestimated they were. *1* <10 € drugs, *2* 10–100 € drugs, *3* 100–1000 € drugs, *4* more than 1000 € drugs, *5* plasma, *6* red cells, *7* platelets, *8* blood derivatives, *9* basic radiology, *10* echo-Doppler, *11* computed tomography/magnetic resonance imaging, *12* specialized radiology, *13* hematology, *14* biochemistry, *15* toxicology, *16* microbiology

Table 4 Average drug estimations

	True costs (€)	Estimation (€)	Deviation (€)	Deviation (%)
Less than 10 €	0.9 ± 0.2	9.3 ± 0.4	8.4 ± 0.4	961 ± 45
10–100 €	29 ± 6	44 ± 1	15 ± 1	51 ± 5
100–1000 €	207 ± 72	103 ± 3	−104 ± 3	−50 ± 2
More than 1000 €	3072 ± 1411	1025 ± 39	−2047 ± 39	−67 ± 1

Results expressed as mean ± SEM

consistently reported in the literature for decades [19, 21, 23]. In our study, the most expensive subgroup of prescriptions ("more than 1000 €" drugs) was the most underestimated, accounting for nearly two-thirds of the underestimation of the global amount. The presence in our questionnaire of five prescriptions exceeding 1000 € might partially explain the worrying estimates we observed. Be that as it may, high-cost drugs are now accounting for a large part of ICU budgets, and focus, more than ignorance, is required to deal with this growing major concern.

One limitation of our study might be that the inaccuracy of the estimations has not been weighted for the frequency of prescriptions or global health care management; both of these parameters are necessary to analyze the economic impact. However, through the two typical clinical cases we chose, our results allow one to indirectly appreciate the value of estimated costs in the real world.

The quite small differences we observed in cost estimation per patient must be read in conjunction with the number of admissions of these patients in ICUs. For example, on the basis of a recent epidemiological study of septic shock in France [33], finding more than 50 patients yearly admitted for septic shock in each center, our results would be relevant with an approximately 10,000 € annual underestimation per ICU. Concerning hemorrhagic shock, such a dramatic amount would be reached with only four underestimations of this clinical situation. Some other limitations must be acknowledged. First, inter-hospital variability of true costs, particularly for drugs and imaging modalities, remains a reality in France, as elsewhere, that might have influenced physicians' estimations. However, these variations can be considered as negligible when compared to the major response errors observed, especially for high-cost prescriptions. Second, we may speculate that responders were probably physicians who were the most concerned by the cost-containment issue. Nevertheless, this potential bias was substantially limited by the high response rate. Third, we have no data on how survey responders were informed on costs in each ICU; yet this factor may have affected cost estimates. Finally, the cost awareness of French physicians might have been influenced by the activity-based financing system; any transposition of our results to another health system remains uncertain.

Improving physicians' cost awareness remains a challenge. Two important approaches can be considered: provide better information and reinforce training. Doctors appear to be predisposed to practice cost-effective medicine, but complain about problems obtaining information about costs [13]. Interventions are needed to provide reliable, easily accessible, and up-to-date cost information in everyday practice. In view of the risks of biased or inaccurate information, physicians appear to prefer academic sources or direct communication with hospital administration [21]. Another information vector could be heath information technology, increasingly used in ICUs. Associated with evidence-based decision support, computerized prescribing software providing fee data has demonstrated an efficacy to achieve cost savings [34–36]. In our study, none of the participating ICUs had adopted such a promising tool, illustrating a dramatic underutilization of cost report software. In addition, it appears essential to reinforce medical education about costs and health care management. In our study, less than 2 % of physicians had an econometrics qualification. It would be desirable for medical educators to offer more courses (in medical school, during residency, and in continuing medical education) dedicated to global health care management and general cost education [37, 38]. Professional cost-consciousness projects, which give a framework for teaching and practicing cost awareness in ICU, could also be an interesting approach [39]. As our results highlight, educational programs dedicated to cost awareness should be particularly targeted at young physicians, who are responsible for a high number of avoidable prescriptions [40, 41]. Further research should also focus on the long-term impact of cost-awareness educational programs and easier access to cost information resources.

In conclusion, this study demonstrates the alarmingly poor awareness of intensivists to costs, especially with regards to high-cost prescriptions. Considerable focus and efforts are still required to strengthen physicians' responsibilities and to incorporate cost control in daily ICU practice.

Conflicts of interest The authors declare they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of our institutional research committee and with the 1964 Declaration of Helsinki and its later amendments. For this type of study formal consent was not required.

Appendix: Co-investigators

Members of the "Costs in French ICU" Study Group (CHU = university hospital, CH = non-university hospital):

CH Alençon: A. Merouani; CHU Amiens: J. Maizel; CHU Angers: L. Masson, A. Mercat; CH Annecy: D. Bougon; CH Annonay: V. Cadiergue; CH Argenteuil: H. Mentec; CH Beauvais: A.M. Guerin; CH Belfort-Montbéliard: M. Feissel; CHU Boulogne-Billancourt: C. Charron; CH Boulogne-sur-mer: R. Pordes; CH Bourg-en-Bresse: N. Sedillot; CHU Brest: J.M. Boles, G. Prat; CH Briançon: B. Langevin; CH Brive-la-Gaillarde: M. Mattei; CHU Caen: M. Jokic; CH Chalon-sur-Saône: J.M. Doise; CH Chambéry: M. Badet, J.M. Thouret; CH Charleville-Mezières: A. Bertrand; CHU G. Montpied, Clermont-Ferrand: A. Lautrette, N. Gazuy, B. Souweine; Hôpital Privé J. Perrin, Clermont-Ferrand: B. Nougarede; CHU Colombes: J. Messika; CH Dax: A. Haffiane; CHU Dijon: M. Freysz, P. Obbée, J.P. Quenot; CH Douai: C. Boulle; CH Draguignan: N. Bele; CHU Garches: J. Aboab; CHU A. Michalon, Grenoble: A.S. Lucas, C. Schwebel, J.F. Timsit; CH Haguenau: F. Kara; CHU R. Salengro, Lille: M. Jourdain; CHU Croix-Rousse, Lyon: G. Bourdin, S. Duperret, C. Guérin, J.C. Richard; CHU E. Herriot, Lyon: T. Baudry, J. Crozon, E. Faucher, B. Floccard, E. Hautin, J. Illinger, J.M. Robert, M. Simon; CHU HFME, Lyon: F. Cour-Andlauer; CHU L. Pradel, Lyon: G. Keller; CHU Lyon Sud: J. Bohé; Hôpital Privé Saint-Joseph Saint-Luc, Lyon: M. Fontaine, S. Rosselli; Hôpital Privé Tonkin, Lyon: F. Salord; CH Mâcon: D. Debatty; CH Melun: M. Monchi; CHU Marseille Nord: L. Papazian, A. Roch; CHU Timone, Marseille: M.

Gainnier; CHU Metz: G. Louis; CH Montélimar: O. Millet; CHU Lapeyronnie, Montpellier: M. Conseil, K. Klouche, K. Lakhal; CHU Guide Chauliac, Montpellier: O. Jonquet, P.L. Massanet; CHU Brabois, Nancy: B. Levy, J.F. Perrier; CHU Central, Nancy: P.E. Bollaert; CHU Nantes: C. Bretonniere; CHU l'Archet, Nice: G. Bernardin, J. Dellamonica, H. Hyvernat; CHU Saint-Roch, Nice: J.C. Orban; CHU, Nîmes: L. Elotmani, J.Y. Lefrant; CH Nouméa: H. Le Coq Saint-Gilles; CHU Cochin, Paris: J.P. Mira; CHU Kremlin-Bicêtre, Paris: N. Anguel, C. Richard; CHU Lariboisière, Paris: B. Megarbane; CHU La Pitié-Salpêtrière, Paris: A. Duguet; CH G. Pompidou: D. Journois; CHU Saint-Louis, Paris: E. Azoulay; CHU Saint-Joseph, Paris: M. Garrouste-Orgeas, S. Hamada; CH Pau: P. Badia; CH Papeete: E. Bonnieux; CH Perpignan: O. De Matteis; CHU Poitiers: F. Petitpas, A. Veinstein; CH Pontoise: E. Boulet; CH La Rochelle: A. Herbland; CH La Roche-sur-Yon: I. Vinatier; CHU Rouen: D. Carpentier, C. Girault; CH Saint-Denis, La Réunion: A. Roussiaux, J. Sudrial; CH Saint-Dizier: S. Wuilbercq; CH Saint-Pierre, La Réunion: A. Winer; CH Toulon: J. Durand-Gasselin; CHU Rennes: A. Gros; CH Roanne: P. Beuret; CHU Saint-Étienne: C. Auboyer, L. Burnol, M. Darmon, E. Diconne, F. Zéni; CH Saint-Malo: J.P. Gouello; CH Saint-Quentin: B. Manoury; CHU Tours: S. Cantagrel; CH Valence: Q. Blanc; CH Versailles: S. Legriel; CH Villefranche-sur-Saône: K. Chaulier.

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