Information asymmetry in hospitals: evidence of the lack of cost awareness in clinicians

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Word count: 3,636

Abstract

Background: Information asymmetries and the agency relationship are two defining features of the healthcare system. These market failures are often used as a rationale for government intervention. Many countries have government financing and provision of health care in order to correct for this, while health technology agencies also exist to improve efficiency. However informational asymmetries and the resulting principal-agent problem still persist, and one example is the lack of cost awareness amongst clinicians. This study explores the cost awareness of clinicians across different settings.

Methods: We targeted four clinical cohorts: medical students, Senior House Officers/Interns, Mid-grade Senior Registrar/Residents, and Consultant/Attending Physicians, in six hospitals in the United Kingdom, the United States, Australia, New Zealand and Spain. The survey asked respondents to report the cost (as they recalled) of different types of scans, visits, medications and tests. Our analysis focused on the differential between the perceived/recalled cost and the actual cost. We explored variation across speciality, country and other potential confounders. Cost-awareness levels were estimated based on the cost estimates within 25% of the actual cost.

Results: We received 705 complete responses from six sites across five countries. Our analysis found that respondents often overestimated the cost of common tests while underestimating high-cost tests. The mean cost awareness levels varied between 4% and 23% for different items. Respondents acknowledged that they did not feel they had received adequate training in cost awareness.

Discussion: The current financial climate means that cost awareness and the appropriate use of scarce health care resources is more paramount than perhaps ever before. Much of the focus of health economics research is on high-cost innovative technologies, yet there is considerable waste in the system with respect to overtreatment and overdiagnosis. Common reasons put forward for this include defensive medicine, poor education, clinical uncertainty and the institution of protocols.

Conclusion: Given the role of clinicians in the health care system, both as agents for patients and for providers, more needs to be done to remove informational asymmetries and improve clinician cost awareness.

Key points of this article for decision makers:

- Only 13% of the estimations provided by the clinicians in our study were within 25% of the actual costs, varying between 4% and 23% for different items.
- Amongst the study participants 74% believed that having access to cost data in provision systems would impact on their decisions.
- Cost awareness training and inclusion of cost approximation in ordering systems contribute to reducing information asymmetry in hospitals.

1. Introduction

Information asymmetry is one of the key features that distinguishes healthcare from a traditional market economy that assumes all parties have access to perfect information [1, 2]. In healthcare, service users lack the medical knowledge that healthcare professionals possess, and this causes information asymmetry. Due to this imbalance of information, patients require health professionals to act in their best interests without any conflict. This is a typical example of the agency relationship. The principal-agent problem arises when there is a conflict of interest between the healthcare user and the clinician [3, 4]. In most countries, healthcare services are regulated by governments and financed by public funds fully or partially in order to prevent this problem.

As well as being agents to patients, in most healthcare systems clinicians also act as agents of the organisations that fund healthcare services since the funders expect clinicians to consider the costs of the services that are offered to healthcare users. In this regard, clinicians are expected to act as "stewards of scarce resources" to reduce healthcare costs [5]. Acting in the best interests of individual patients, while also considering the limited resources available for population healthcare needs, requires an understanding of health economics (or at the very least opportunity cost) and a form of cost awareness amongst clinicians. Recognising this, health economics is taught as part of undergraduate medical training in some countries. In the UK, the General Medical Council requires newly qualified doctors to be able to apply the principles underlying the development of health and health service policy, including issues relating to health economics [6]. Providing cost-conscious care is considered a key competency for doctors in most countries, including the USA and Spain [5, 7, 8].

Some studies have shown that clinicians acknowledge preventing unnecessary resource use as part of their responsibility [9, 10]. However, the existing evidence suggests there are low levels of cost awareness amongst clinicians. One systematic review revealed that only 33% of doctors provided an estimate within 20% or 25% of the actual diagnostic costs [11]. This figure was only 16% for consumables and medications in a national survey of 139 UK urologists [12]. There is limited evidence on the factors contributing to the lack of cost awareness. In a large study, that included 2,556 physicians and 3,395 medical students from the USA, medical student respondents were more likely than the qualified doctors to agree that the cost to society should be considered in treatment decisions [13]. However, it is difficult to generalise these results to other settings.

The Good Stewardship Working Group identified the top five primary care procedures which are overused and the cost of these procedures was estimated at $5.8 billion per year in the US in 2011 [14, 15]. Increasing financial constraints and the COVID-19 pandemic have elevated the need to provide cost-conscious care globally. This study aimed to explore cost awareness amongst clinicians practising in the UK, US, Australia, New Zealand, and Spain. A secondary aim was to explore the differences in cost awareness based on speciality, country and clinician seniority and to explore the relationship between reported importance of cost and cost awareness. This study is the first step in an investigation of what factors are associated with greater awareness of costs in different countries, to ultimately inform strategies to improve clinician awareness of costs.

2. Methods

2.1. Study design and respondents

A survey (Supplementary Material) was designed and applied using a digital platform and kiosk technique [16]. The data collection teams approached individuals in the hospitals to take part, based on opportunistic sampling. The survey asked respondents to "give your best approximation of the costs entailed in the following healthcare tests, episodes or events", which included items such as full blood count, troponin, chest X-ray and electrocardiogram. The kiosk approach meant respondents could not pause the survey and seek out the actual cost; rather, it was entirely based on their knowledge and recall. The survey was conducted face-to-face. No time limits were set on any answer providing individuals with sufficient time to think about their answers in an unpressured setting. The survey also included questions on training in cost awareness, the influence of ordering system cost alerts and five-point Likert scale questions on the importance of costs [17]. The study included four clinical cohorts: medical students, Senior House Officers/Interns, mid-grade Senior Registrars/Residents, and Consultants/Attending Physicians in six hospitals in the UK (n=2), US, Australia, New Zealand, and Spain between June 2020 and February 2021. This study was considered an evaluation and deemed exempt from ethical approval by the Royal Free London NHS Foundation Trust.

2.2. Outcomes and analysis

The knowledge of cost was used as an indicator of cost-awareness in this study. Actual costs were requested from the finance departments of each hospital site (Australia, New Zealand, Spain and USA) or obtained from national published sources (UK). The financial departments requested the cost information kept confidential since they were actual costs rather than prices. The main outcome was the differential between the perceived and actual cost. To address any exchange rate issues we chose to reflect this variability using (1) the ratio of estimated costs to actual costs, such that a number greater (less) than 1 reflects over (under) estimation, and (2) whether the estimated costs were within ±25% of the actual cost for each item ('costs in range', CIR). The ratio and proportion of CIR are reported for each resource item, and compared across country, current role (qualified vs. student), clinical specialty, availability of cost approximation in ordering systems and perceived importance of cost. Significant differences across these categories were identified using the F-test to compare means (for the ratio) and chi-squared test of independence (for ±25%). We also used multivariate regression analysis (ordinary least squares and logistic) to explore if certain respondent characteristics played a greater or lesser role than others in determining the variation between estimated and actual cost.

3. Results

3.1. Respondent characteristics and perceptions on cost awareness

In total, 705 respondents from six hospitals in five countries completed the survey. Table 1 summarises the characteristics of the respondents and the responses to the perception statements. The highest number of the respondents were practicing in the UK (n = 219), followed by those working in New Zealand (n = 127). Most respondents had ten years or less experience (73%) and 17% were medical students.

Although only 23% of the clinicians had access to an ordering system which provided cost approximation, 74% of the respondents felt that having cost approximation as part of the ordering system would impact on their decision-making. While 79 of respondents without access to cost approximations felt that the system would be impactful, of those with access only 60% felt it influenced their decisions. With respect to the importance of costs, for non-urgent tests 84% of the respondents thought it was important (40% very important), while for urgent tests this value was 40% (10%). Around half of the respondents felt that they had received adequate training while 36% did not.[1]

[1] This question was added later to the survey, hence some participants were not asked this.

3.2. Cost awareness amongst clinicians

Overall, 13% of estimates were within 25% of the actual cost with a range of 4% to 23% depending on the individual item (Table 2). The highest rate of accurate estimates were found for an outpatient visit, chest X-ray, full blood count, blood culture and CT head scan while the lowest rates were for urinary dipstick pregnancy test, dipstick urinalysis and intravenous paracetamol. The ratio of estimated to actual cost demonstrated a very positively skewed distribution with some estimates from individual clinicians very high relative to the actual. For example, while the mean estimated cost of a full blood count is double that of the actual, some estimates were more than 200-fold higher than their actual.

Respondents overestimated 15 out of the 17 costs, overall ratio of 0.80 (SD 0.85), with the greatest overestimate seen for intravenous cefuroxime (ratio 12.2, SD 66.7, Table 2). The only items that were underestimated, coronary angiogram (ratio 0.69, SD 1.29) and packed red blood cells (0.78, SD 0.83), and the item most accurately estimated, general outpatient visit (1.16, SD 1.33), were also the three most expensive items.

3.3. Factors that affect cost awareness

The ratio of estimated and actual costs and the proportion of CIR across different respondent characteristics are provided in Tables 3a and 3b, respectively.

The country of practice is significantly correlated with cost awareness levels for all items. Overall cost awareness was highest in hospitals in Oceanic countries with overall CIR rates of 24% and 26% in Australia and New Zealand, respectively. However, even these hospitals had relatively low CIR rates, at most 35% for the best-estimated cost, a unit of red blood cells (Table 3b). In keeping with this, the mean estimate:actual cost ratio for Australia and New Zealand was 1.39 (SD 1.31) and 0.86 (SD 0.61), respectively. In comparison, the hospital in the USA showed much less accurate estimates with an 3% CIR rate and an overall cost estimate ratio of 0.28 (SD 0.25). Interestingly, Australia was the only country to overestimate costs overall (mean cost estimate ratio 1.39) while all other countries underestimated with ratios ranging from 0.28 to 0.86.

In terms of the qualifications and characteristics of respondents, current role (studying or practicing) and primary area of expertise were related with similar margins of accuracy (Table 3b). While anaesthetists had the lowest extent of overestimation (overall ratio 2.18), they were also the least likely to accurately estimate a cost (12.8% CIR rate, overall), while surgeons and medical clinicians overestimated the most (ratio 4.37 and 4.66, respectively) they were more likely to have an in-range cost estimate. Although students tended to overestimate the cost to a greater extent than clinicians (overall ratio 3.88 vs. 3.52), this difference appeared to be driven by much lower estimates provided by anaesthetic respondents (Table 3a). Experience in terms of years working (or studying) had little impact on cost awareness. Provision of cost approximation information in the ordering system had varying impacts for different items, and this also varied depending on whether considering the ratio or the margin of accuracy. Overall, respondents who had access to cost approximations were slightly more likely to estimate a CIR (15.4% vs. 12.9%) but these estimates were much higher (ratio 5.57 vs. 3.00). The perception of having adequate training in cost awareness did not have a significant association with respondent responses.

The final analyses consider all these factors simultaneously. A series of logistic regressions were conducted for specific items which were selected based on cost and frequent usage. For the sake of brevity, the regression results for specific items (coronary angiogram, outpatient visit, one unit of red blood cells, troponin and clotting screen) are reported in Table 4 as these provide information with respect to some of the most expensive or most commonly requested items while the regression results for the remaining items are provided in the Supplementary Material. It was evident that country of medical practice explained much of the variation in cost awareness. However, the impact varied from one item to another. Compared to clinicians practising in the UK, those in Australia had higher levels of cost awareness regarding the cost of an angiogram, troponin and clotting screen while those from New Zealand had a higher awareness of the cost of a unit of red blood cells. On the other hand, the cost awareness levels of respondents from New Zealand and Spain were significantly lower than those in the UK regarding outpatient costs. Additionally, those working in the US had a substantially lower level of awareness of angiogram and troponin costs compared to the clinicians practising in the UK. Interestingly, the regression analysis found that provision of cost information did not have any significant impact on the cost awareness levels.

4. Discussion

This study aimed to explore cost awareness amongst clinicians from five countries as an indicator of information asymmetry in hospitals with respect to finances. The findings show that despite the updates to medical training and international recognition of the importance of health economics, cost awareness and general austerity, there is still a lack of awareness amongst clinicians. The respondents substantially overestimated the cost of most items and underestimated the cost of two procedures which were amongst the most expensive items in the survey.

Our analyses suggested that cost awareness varied based on the clinical procedure, while the impact of country of practice, perceived adequacy of training in cost awareness, role, clinical speciality, experience and accessibility of cost data on cost awareness differed from one item to another. Cost awareness of commonly ordered or used items such as chest X-rays, full blood count and CT head scans was relatively high while common tests which are not performed or physically ordered by hospital clinicians, such as urinary dipstick pregnancy and urinalysis, had correspondingly lower degrees of cost awareness. Considering the significant impact of having a cost-approximation on the ordering systems, this might possibly be due to retention of information from recurrent exposure to cost information systems either currently or in previous hospitals.

The regression analyses showed that the most important factor in cost awareness was the country of practice although its impact was different for different items. This may be explained by the differences in the funding and structure of healthcare systems. For example, the respondents from USA where the payer is usually a private insurance company and costs are notoriously variable and generally higher than in other countries had significantly lower levels of cost awareness compared to those in the UK where single-payer healthcare system means costs are more uniform. However, data from the Australian system which is part-private and part-public funded, showed a general over-estimation of costs. Given the variability in the actual costs and payment systems across countries, it may be that these different payment methods impact awareness for example, performance-based payment has been found to increase cost awareness [18], our study, however, was not set up to consider that complexity.

4.1. Study findings in the context of existing literature

The overall cost awareness observed in this study was low, varying between 4% and 23% for different procedures. The overall awareness of diagnostic and nondrug therapeutic costs was reported as 33% in a systematic review when cost accuracy was defined as 20-25% of the actual cost in 14 studies from different settings [11]. While our results are not directly comparable because the studies included in that review focussed on different procedures and settings, our findings do concur.

Previous studies have identified poor access to information on costs as a key reason behind low levels of cost awareness [19]. It has been shown that clinicians change their decision-making when cost information is available [20-24]. In line with this, 74% of the clinicians in this study thought that the provision of cost approximation would impact on their decision making although access to cost approximation does not appear to lead to cost awareness. Hence, efforts to improve cost awareness in clinicians should not seek to replace point-of-ordering reminders and cost information..

Additionally, some costs were more accurately estimated by respondents from countries with low rates of access to cost information when ordering, although the majority (90%) of respondents who had access to cost information were working in the UK or Australia. Therefore, although cost approximation is important other factors such as country of practice are more likely to contribute to the international variability.

Similarly, training in cost awareness did not have a statistically significant impact on the cost estimates in this study. Other solutions to correct for this information asymmetry appear necessary, otherwise cost awareness will not improve and will not be reflected in clinical decision making, such that attempts to address excessive healthcare resource use and cost at the individual patient-level will be unsuccessful.

4.2. Strength and limitations

To the best of the authors' knowledge, this is the first cross-national survey of cost awareness amongst physicians. The survey was performed face-to-face in a kiosk format and real time data capture removed the opportunity for respondents to look up or research cost information. Respondent selection bias should be considered given that effectively an unselected cohort from the available clinical staff was included in the study. However, it might be that those who participated in the study were more interested in the topic and hence had a higher cost-awareness than the non-respondents. The individuals performing the questionnaire approached staff at hospital sites where staff from all specialities were mixed (i.e. canteens). The individuals performing the questionnaire were junior members of staff who would not recognise the majority of staff they approached. Hence, this sampling approach should generate a reasonably unbiased sample of the staff population. Notably, the cost-awareness levels estimated in this study were much lower (between 4% and 23%) than the estimates in previous studies (20%-33%), although the potential impacts of this on the factors that affect cost-awareness is not known. The face-to-face element of the study also permitted respondent questions and clarification to improve the data quality and accuracy.

There are some limitations to be acknowledged. Only a limited number of doctors participated in this study from five countries. Hence the findings may not be generalisable either at national or international level. Another consideration is that the statement regarding adequate training in cost awareness was added to the survey later in the data collection. Thus, the participants from Australia and Spain and around half of those from the UK were not asked this question, as such the impact of the perception of adequate training was not assessed for these participants.

There is no standardised measure of cost awareness amongst clinicians. The survey asked about the 'cost entailed' and estimates of these were compared to actual costs. We employed the ratio of estimated costs to the actual costs and the proportion of estimates within 25% of the actual costs which is in line with previous published papers and avoids issues with the variation in item costs [12, 19]. Because of this variation in costs (a coronary angiogram is 1000 times more costly than the least expensive item) the CIR and ratio estimates for the overall cost were skewed towards the most expensive item and these should be interpreted carefully. One solution to this would be to obtain the frequency of these procedures over a period of time (or for a typical consultation/inpatient stay) and this would allow researchers to calculate a weighted aggregate cost which could be compared across respondents' characteristics.

A final limitation of our research is that respondents were asked to provide a 'cost'. The distinction between the cost and the price of (or charge for) healthcare is a key issue in health economics [25, 26] but conveying this nuance to clinicians, although important, was outside of the scope of the survey. We acknowledge that in some of the countries included in our sample there is a price for health care which is similar to the cost (those within public system, although even the published price may be a 'list' price), while those who practice in the private sector (or have sessions in the independent sector as is common in the UK, New Zealand and Australia) may be more au fait with the price charged to patients, rather than the cost as economist would define it. This may have introduced confusion when asking for the cost of healthcare - respondents may have provided the price of healthcare. We acknowledge this and future surveys should think about how to avoid this with different or more refined terminology

4.3. Implications

The existing evidence suggests that reducing information asymmetry by increasing cost awareness amongst clinicians would reduce unnecessary resource use [14, 27, 28]. In addition, during economic evaluations that involve clinicians, a considerable amount of time is spent discussing the key tenants of health economics. Hence, increasing cost-awareness amongst clinicians would enable more collaborative work and save time and effort.

The existing evidence suggests that even a brief educational intervention can impact on clinicians' knowledge of drug costs and foster willingness to consider costs when prescribing [29]. Hence, it can be argued that medical students need additional training in health economics and practicing clinicians need to undertake some refresher training, in order to increase their awareness of health economics and provide an understanding of opportunity cost and the need to contain costs. This could reduce information asymmetry by educating the agent in the principal-agent relationship.

Although the need for teaching health economics in medical schools has been recognised widely, there are considerable variations across different settings. Additionally, the evidence suggests that students who are taught by a health economist perform better in health economics exams [30]. As part of the ongoing endeavour to build an international network of health economics teaching, the International Health Economics Association (iHEA) website features a detailed section which provides teaching materials [31]. The University of Sheffield School of Health and Related Research (ScHARR) offers an open-access online learning course on health technology assessment[32]. Promotion of these sources globally would increase the accessibility of health economics knowledge and contribute to increasing cost awareness amongst clinicians.

An alternative might be to design a system that minimises or controls over-ordering, over-prescribing (e.g. moral hazard) and encourages cost-effective alternatives, such that the agent's decision making is constrained by the principal. However, this may present moral or clinical concerns if clinicians feel that optimal clinical care is being constrained by the workplace, regardless of whether this is for economic or utilitarian good.

5. Conclusion

Cost awareness amongst clinicians is still low despite the international recognition of understanding and applying health economics evidence as a required skill. The differences in cost-awareness amongst study participants were mostly explained by the country of practice. This study identifies two important approaches which can contribute to reducing information asymmetry in hospitals: provision of cost information in ordering systems and training medical students and clinicians.

Declarations

Funding: No funding was received for this study.

Conflicts of interest/Competing interests: The authors declare no conflict of interest.

Availability of data and material: The dataset cannot be shared due to the risk of exposing commercially sensitive information.

Code availability: Not applicable

Authors' contributions: JF, MS and the Health Economics Survey Group designed the study and collected the data. TSA and PL conducted the analysis. TSA wrote the manuscript and PL, JF,MS, JS, TF, HE, SE, and AH contributed.

Ethics approval: Not required since the study was a service evaluation.

Consent to participate: All clinicians provided verbal consent.

Consent for publication: The data collection teams were clear to participants that the findings from this project would be published. The article doesn't include any identifying information or images. Responding to the survey was implied consent for publication.

Table 1 Occupational information and perceptions on costs and cost awareness

Variables/statements		**Number**	**Percentage (%)**
Country of practice	Australia	122	17
	New Zealand	127	18
	Spain	120	17
	United Kingdom	219	31
	United States of America	117	16
	Total	705	
Current roles	Qualified/registered doctor	585	83
	Medical student	116	17
	Total	701	
Primary expertise	Anaesthetics/Intensive Care	253	36
	Emergency Medicine	21	3
	Medical Student	112	16
	Surgery	191	27
	Medicine	125	18
	Total	702	
Experience (years in training if student)	Five years or less	328	47
	6- 10 years	177	26
	11 - 19 years	139	15
	20 years or more	90	12
	Total	700	
Do your test ordering systems provide a cost approximation as part of the ordering?	Yes	159	23
	No	544	77
	Total	703	
If a cost approximation was available, do you think that would impact on your decision-making?	Yes	524	74
	No	180	26
	Total	704	
How important are the costs of urgent tests?	Very important	67	10
	Somewhat important	117	16
	Important	95	14
	Low importance	221	31
	Very low importance	202	29
	Total	703	
How important are the costs of non-urgent tests?	Very important	280	40
	Somewhat important	79	10
	Important	239	34
	Low importance	98	14
	Very low importance	16	2
	Total	704	
I feel that I have had enough training in cost awareness. *(This question was asked only to participants from the UK, New Zealand and USA.)*	Strongly agree	10	3
	Agree	173	49
	Neither agree nor disagree	46	13
	Disagree	3	1
	Strongly disagree	122	35
	Total	354	

Table 2 Accuracy of estimated costs

Item	Estimated cost/ actual cost Mean (SD)	Estimates within 25% of actual costs
Full blood count (FBC)	2.06 (3.85)	17%
Basic clotting screen (Prothrombin - PT and Activated Partial Thromboplastin Clotting - APTT only)	1.4 (1.38)	11%
Group and screen/Type and screen	1.39 (2.75)	15%
Blood culture (pair)	1.84 (2.44)	17%
Troponin	1.24 (3.19)	15%
Chest X-ray (departmental, not portable)	1.63 (1.90)	20%
CT head scan (non-contrast, including report)	1.77 (2.27)	17%
Simple trans-thoracic echocardiogram (including sonographer time and report - ECHO)	2.00 (5.88)	13%
Coronary angiogram	0.69 (1.29)	13%
General outpatient visit	1.16 (1.33)	23%
Urinary dipstick pregnancy test (human chorionic gonadotropin - HCG)	5.62 (12.65)	4%
Electrocardiogram (ECG)	2.46 (8.00)	13%
Dipstick urinalysis (protein, blood, etc.)	10.35 (26.34)	7%
1.5g cefuroxime (intravenous)	12.20 (66.94)	9%
1g IV paracetamol (acetaminophen)	6.01 (15.11)	8%
1000ml Hartmann's solution (or equivalent)	8.45 (19.21)	11%
1 unit packed red blood cells	0.78 (0.83)	16%
Overall	0.80 (0.85)	19%

Table 3a Impact of respondent characteristics on selected cost estimates – Estimated costs/Actual costs Mean (SD)

	FBC	PT & APTT	Group & screen	Blood culture	Troponin	Chest X-ray	CT head	ECHO	Coronary angiogram	Outpatient visit	Pregnancy Test	ECG	Dipstick urinalysis	Cefuroxime	Paracetamol	Hartmann’ s	Red blood cells
Country																	
Australia	0.77(0.6)	1.38(0.9)	0.73(0.5)	2.28(1.8)	1.30(1.5)	1.05(0.7)	0.83(0.8)	4.16(4.09)	1.76(2.62)	1.25(0.8)	3.93(3.4)	1.23(1.3)	15.08(14.4)	55.2(154.7)	17.37(28.8)	22.30(32.3)	1.38(0.91)
New Zealand	2.58(3.4)	1.78(1.9)	1.49(1.7)	2.63(2.7)	2.83(6.8)	2.24(2.4)	2.65(2.4)	1.35(1.17)	0.65(0.66)	0.69(0.9)	1.74(2.2)	0.36(0.6)	0.57(0.6)	2.18(3.2)	4.74(7.24)	7.38(12.7)	1.78(1.97)
Spain	5.69(6.8)	1.74(1.7)	4.05(5.2)	3.31(2.4)	1.39(1.7)	2.02(2.1)	1.25(0.8)	0.83(1.01)	0.42(0.48)	0.62(0.4)	4.44(5.5)	0.83(1.2)	0.36(0.5)	10.7(9.9)	11.01(14.6)	11.81(16.1)	1.75(1.68)
UK	1.33(2.2)	0.47(0.7)	0.89(1.5)	1.71(2.9)	0.74(1.1)	1.87(2.1)	2.86(3.0)	2.81(9.74)	0.48(0.61)	1.60(1.9)	12.4(20.4)	6.36(13.5)	22.0(42.8)	0.41(0.7)	0.74(1.4)	3.28(14.4)	0.47(0.74)
USA	0.45(0.9)	0.21(0.2)	0.16(0.2)	0.26(0.3)	0.29(0.4)	0.72(0.7)	0.33(0.4)	0.13(0.15)	0.28(0.39)	1.27(1.3)	0.12(0.1)	0.36(0.4)	4.51(5.5)	2.46(2.9)	0.37(0.5)	1.46(2.6)	0.21(0.26)
p value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Current role																	
Qualified doctor	1.79(1.1)	0.95(0.5)	1.26(0.1)	1.72(0.1)	1.03(0.5)	1.51(0.1)	1.76(0.1)	2.10(0.3)	0.74(0.6)	1.21(0.1)	5.42(0.5)	2.18(0.3)	10.33(1.1)	13.19(3.0)	6.21(0.6)	7.62(0.8)	0.83(0.0)
Medical student	3.44(0.5)	1.51(0.15)	2.04(0.3)	2.40(0.3)	2.37(0.7)	2.21(0.2)	1.85(0.2)	1.52(0.2)	0.44(0.1)	0.86(0.1)	6.76(1.1)	3.77(0.7)	10.62(1.8)	7.46(1.1)	5.15(0.8)	12.91(2.2)	0.62(0.1)
p value	0.00	0.00	0.01	0.01	0.00	0.00	0.69	0.34	0.02	0.01	0.33	0.05	0.91	0.40	0.49	0.01	0.01
Expertise																	
Anaesthetics/IC	1.44(2.6)	0.75(1.1)	0.84(1.4)	1.52(1.9)	0.86(1.2)	1.46(1.6)	1.93(2.4)	1.44(2.0)	0.62(0.8)	1.38(1.8)	4.21(8.8)	2.00(4.1)	8.16(21.0)	3.59(9.8)	2.84(7.7)	3.06(12.6)	0.95(0.75)
Emergency	0.89(1.0)	1.10(0.8)	0.87(1.6)	1.87(1.4)	0.86(0.5)	0.90(0.6)	0.73(0.5)	3.18(2.6)	1.39(1.5)	1.36(0.9)	3.36(3.4)	0.74(0.7)	8.38(8.3)	3.37(51.2)	14.78(17.1)	14.86(19.8)	0.63(1.0)
Surgery	2.92(4.4)	1.33(1.8)	2.45(5.0)	2.26(3.1)	1.49(1.8)	2.04(2.6)	2.03(2.6)	2.66(12.5)	0.56(0.66)	1.02(1.1)	9.04(22.4)	2.41(5.9)	15.88(47.7)	10.32(34.0)	7.45(15.1)	9.72(17.6)	0.82(0.9)
Medicine	1.71(3.6)	0.98(1.3)	1.26(2.11)	1.65(1.6)	1.03(1.3)	1.32(1.2)	1.47(1.5)	2.46(4.1)	0.95(2.11)	1.06(1.2)	5.10(8.14)	2.40(12.2)	9.34(15.6)	25.6(122.3)	9.24(22.7)	12.96(26.6)	0.72(0.9)
p value	0.00	0.00	0.00	0.01	0.00	0.00	0.03	0.16	0.00	0.00	0.01	0.30	0.11	0.01	0.00	0.00	0.00
Experience																	
Five years or less	2.02(3.9)	1.08(1.5)	1.36(2.2)	1.83(2.6)	1.36(4.4)	1.68(2.2)	1.67(2.4)	2.24(8.3)	0.65(1.4)	1.11(1.2)	5.70(15.1)	2.86(10.9)	10.72(27.5)	17.68(96.0)	5.19(10.2)	10.69(23.4)	1.08(1.48)
6-10 years	2.00(3.3)	1.04(1.2)	1.63(3.6)	1.86(2.2)	1.13(1.5)	1.51(1.5)	1.78(2.0)	1.72(1.9)	0.70(0.9)	1.24(1.4)	6.34(11.7)	2.33(4.6)	11.63(29.5)	8.63(18.2)	9.16(24.5)	8.13(18.7)	1.04(1.20)
11 - 19 years	2.11(4.7)	0.86(1.3)	1.18(2.1)	1.75(2.2)	1.07(1.0)	1.70(1.8)	2.22(2.6)	2.20(.2.7)	0.75(0.9)	1.44(2.2)	5.48(7.05)	2.68(4.5)	9.85(17.6)	7.01(24.7)	4.47(8.9)	4.84(6.8)	0.86(1.32)
20 years or more	2.38(3.9)	1.09(1.4)	1.29(3.2)	1.11(1.2)	1.33(1.9)	1.60(1.8)	1.66(1.9)	1.43(1.8)	0.59(0.6)	0.80(0.6)	4.09(9.21)	1.02(1.6)	6.75(24.5)	5.65(9.6)	4.81(10.8)	5.42(10.6)	1.09(1.46)
p value	0.93	0.53	0.56	0.98	0.80	0.77	0.16	0.59	0.0	0.00	0.59	0.28	0.53	0.25	0.02	0.02	0.53
Cost approximation available																	
Yes	0.77(0.1)	0.77(0.6)	0.68(0.1)	1.53(0.1)	0.75(0.1)	1.09(0.1)	1.36(0.1)	3.07(0.3)	1.18(0.2)	1.27(0.1)	5.72(0.6)	3.07(0.1)	14.23(1.5)	34.3(11.0)	9.29(1.5)	14.9(2.6)	0.64(0.8)
No	2.43(0.2)	1.12(0.6)	1.60(0.1)	1.93(0.1)	1.39(0.2)	1.79(0.1)	1.90(0.1)	1.69(0.3)	0.54(0.03)	1.12(0.1)	5.59(0.6)	2.28(0.3)	9.24(1.2)	5.89(0.5)	5.05(0.6)	6.53(0.5)	0.84(0.3)
p value	0.00	0.01	0.00	0.06	0.03	0.00	0.01	0.01	0.00	0.20	0.92	0.28	0.04	0.00	0.00	0.00	0.01
Cost awareness training (This question was asked only to participants from the UK, New Zealand and USA)																	
Agree	1.34(2.8)	0.61(0.8)	0.54(0.5)	0.85(0.1)	0.98(1.4)	1.21(0.7)	1.39(1.1)	0.88(0.6)	0.37(0.5)	0.89(0.8)	4.02(5.2)	0.99(1.3)	3.49(3.3)	0.74(0.83)	3.37(5.3)	4.08(6.8)	0.77(0.7)
Strongly agree	0.89(1.2)	0.26(0.2)	0.40(0.3)	1.46(1.5)	0.71(1.1)	1.48(1.5)	1.12(1.3)	0.93(1.0)	0.47(0.3)	2.47(1.7)	0.46(0.4)	0.5(0.3)	7.57(9.3)	2.68(4.3)	1.01(0.8)	4.98(3.1)	0.65(0.6)
Neither	1.22(2.6)	0.74(1.7)	0.82(0.3)	1.36(1.9)	0.96(1.8)	1.26(1.1)	1.82(1.2)	1.62(3.1)	0.44(0.5)	0.98(0.9)	1.99(2.5)	5.41(24.5)	4.86(6.9)	1.63(3.5)	2.95(9.4)	2.19(2.7)	1.07(1.1)
Disagree	1.30(2.6)	0.75(1.3)	0.71(1.0)	1.34(1.9)	1.47(5.8)	1.56(2.1)	1.91(2.4)	1.33(2.3)	0.51(0.6)	1.18(1.3)	3.72(8.6)	1.82(4.4)	8.65(23.1)	1.73(2.9)	1.83(3.8)	3.54(7.23)	0.78(0.7)
Strongly disagree	0.33(2.4)	0.89(1.5)	0.97(2.1)	1.45(2.5)	1.02(1.6)	1.55(1.7)	2.01(2.9)	2.28(12.8)	0.48(0.7)	1.18(1.3)	3.36(10.0)	1.22(2.6)	6.34(21.7)	1.77(2.2)	1.90(3.5)	6.21(20.8)	0.87(0.8)
p value	0.04	0.84	0.61	0.94	0.89	0.86	0.91	0.87	0.92	0.34	0.75	0.13	0.75	0.44	0.56	0.38	0.27

Table 3b Impact of respondent characteristics on selected cost estimates – Percentage of estimates within 25% of actual costs

	FBC (%)	PT & APTT (%)	Group & screen (%)	Blood culture (%)	Troponin (%)	Chest X-ray (%)	CT head (%)	ECHO (%)	Coronary angiogram (%)	Outpatient visit (%)	HCG (%)	ECG (%)	Dipstick urinalysis (%)	1.5 cef IV(%)	1g IV para. (%)	1000ml Hartmans (%)	1 unit blood cells (%)
Country																	
Australia	26	28	18	28	25	30	20	6	26	27	7	21	4	1	2	0	11
New Zealand	21	8	29	12	13	11	20	24	11	18	6	7	13	19	12	8	35
Spain	8	13	13	14	17	22	38	17	13	10	11	21	12	9	10	2	12
UK	17	7	12	22	16	19	9	16	15	31	0	8	4	7	12	23	8
USA	10	2	2	6	3	20	7	0	1	22	0.1	11	7	12	2	16	21
p value	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Current role																	
Qualified doctor	18	10	14	18	15	20	18	13	14	22	4	12	7	9	10	11	18
Medical student	9	14	18	11	16	19	16	14	10	26	4	15	9	9	3	12	8
p value	0.01	0.29	0.26	0.06	0.86	0.79	0.75	0.78	0.16	0.41	0.92	0.52	0.59	0.93	0.03	0.81	0.01
Expertise																	
Anaesthetics/IC	17	6	10	15	13	15	12	12	13	24	4	12	6	10	9	15	24
Emergency	24	29	29	33	10	43	24	5	10	19	10	14	5	10	10	0	10
Surgery	22	13	15	16	14	16	16	13	10	22	5	15	8	7	11	11	16
Medicine	17	14	17	23	19	27	26	14	18	24	4	18	9	8	9	8	12
p value	0.09	0.00	0.04	0.02	0.32	0.00	0.00	0.78	0.13	0.99	0.73	0.82	0.59	0.88	0.30	0.13	0.00
Experience																	
Five years or less	14	12	15	17	14	21	17	13	11	24	5	10	7	10	8	11	12
6-10 years	19	11	16	18	13	20	15	15	18	21	3	14	6	10	10	10	16
11 - 19 years	17	9	11	16	22	17	16	10	16	22	2	18	10	6	8	16	24
20 years or more	23	10	14	16	13	17	23	14	11	22	8	7	7	9	9	9	24
p value	0.14	0.89	0.78	0.95	0.19	0.71	0.04	0.54	0.18	0.91	0.16	0.08	0.59	0.57	0.78	0.32	0.00
Cost approximation available																	
Yes	18	18	13	30	17	22	18	13	18	30	5	16	3	7	8	13	12
No	16	9	15	14	14	19	17	13	12	21	4	12	8	10	8	11	17
p value	0.54	0.00	0.04	0.00	0.37	0.45	0.92	0.87	0.05	0.02	0.51	0.13	0.02	0.25	0.91	0.64	0.11
Cost awareness training (This question was asked only to participants from the UK, New Zealand and USA.)																	
Agree	0	10	30	0	0	0	40	30	0	0	10	20	0	20	10	30	30
Strongly agree	0	0	0	33	0	33	0	0	33	33	0	33	33	15	3	0	0
Neither	10	4	11	17	7	22	15	15	9	28	2	9	9	7	15	15	15
Disagree	19	6	12	13	8	14	10	14	12	22	3	12	8	14	10	17	23
Strongly disagree	12	4	18	14	9	16	12	13	7	25	1	5	7	0	0	12	25
p value	0.08	0.79	0.29	0.54	0.93	0.40	0.08	0.61	0.30	0.38	0.38	0.12	0.41	0.57	0.09	0.50	0.57

Table 4 Estimated costs/actual costs - Logistic regression analysis

Predictor variable	PT&APTT β (SE)	Troponin β (SE)	Coronary Angiogram β (SE)	Outpatient visit β (SE)	1 unit blood cells β (SE)
Country					
UK	Ref.	Ref.	Ref.	Ref.	Ref.
Australia	1.57 (0.38)*	0.81 (0.32)*	1.05 (0.33)*	-0.27 (0.28)	0.40 (0.43)
New Zealand	0.03 (0.45)	-0.59 (0.35)	-0.43 (0.37)	-0.82 (0.30)*	1.74 (0.35)*
Spain	0.38 (0.42)	-0.01 (0.34)	-0.04 (0.36)	-1.45 (0.36)*	0.56 (0.42)
USA	-1.44 (0.78)	-1.89 (0.56)*	-3.12 (1.03)*	-0.51 (0.30)	0.95 (0.38)*
Expertise					
Anaesthetics/I. Care	Ref.	Ref.	Ref.	Ref.	Ref.
Emergency Medicine	0.68 (0.66)	-1.18 (0.83)	-1.52 (0.83)	-0.62 (0.70)	-0.39 (0.83)
Student	0.82 (0.46)	0.01 (0.40)	-0.63 (0.44)	0.03 (0.32)	-0.84 (0.43)
Surgery	0.43 (0.41)	0.17 (0.32)	-0.22 (0.32)	0.07 (0.27)	-0.51 (0.32)
Medicine	0.69 (0.44)	-0.04 (0.37)	-0.61 (0.40)	0.14 (0.30)	-0.21 (0.33)
Experience					
Five years or less	Ref.	Ref.	Ref.	Ref.	Ref.
6-10 years	0.20 (0.33)	-0.33 (0.30)	0.44 (0.30)	0.01 (0.25)	0.13 (0.30)
11-19 years	0.41 (0.44)	0.68 (0.34)*	0.24 (0.38)	-0.08 (0.30)	0.62 (0.33)
20 or more	0.21 (0.49)	0.36 (0.41)	0.04 (0.44)	0.22 (0.33)	0.48 (0.35)
Importance of cost for urgent tests					
Very important	Ref.	Ref.	Ref.	Ref.	Ref.
Somewhat important	0.23 (0.62)	0.30 (0.48)	-0.34 (0.47)	0.27 (0.44)	0.10 (0.58)
Important	0.23 (0.66)	0.15 (0.47)	-0.10 (0.44)	0.55 (0.42)	0.80 (0.54)
Low importance	0.57 (0.55)	0.27 (0.43)	-0.30 (0.41)	0.78 (0.38)*	0.60 (0.53)
Very low importance	0.94 (0.53)	0.39 (0.44)	-0.53 (0.42)	0.63 (0.39)	0.20 (0.55)
Importance of cost for non-urgent tests					
Very important	Ref.	Ref.	Ref.	Ref.	Ref.
Somewhat important	-0.37 (0.42)	-0.06 (0.37)	0.01 (0.38)	0.01 (0.31)	-0.10 (0.34)
Important	1.22 (0.45)	0.13 (0.37)	-0.11 (0.39)	0.19 (0.32)	0.00 (0.35)
Low importance	-0.51 (0.52)	-0.16 (0.48)	-0.58 (0.53)	0.37 (0.40)	-0.29 (0.56)
Very low importance	-0.36 (0.90)	0	0	-0.76 (0.84)	-0.62 (0.80)
Cost approximation available					
Yes	Ref.	Ref	Ref.	Ref.	Ref.
No	0.12 (0.37)	-0.41 (0.33)	0.17 (0.33)	0.09 (0.26)	0.47 (0.37)
Cost provision would impact decision					
Yes	Ref.	Ref.	Ref.	Ref.	Ref.
No	0.21 (0.31)	0.64 (0.29)	0.34 (0.27)	0.19 (0.23)	0.47 (0.30)

***p<0.05**

Current role and cost awareness training were excluded from this analysis because they were correlated with expertise (p<0.05).

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