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

2

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31

32 **Abstract**

33

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

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

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

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

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

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59

60 **Key points of this article for decision makers:**

- 61 • Only 13% of the estimations provided by the clinicians in our study were within 25% of the
62 actual costs, varying between 4% and 23% for different items.
- 63 • ~~Amongst the study participants 74% believed that having the country of practice and access~~
64 ~~to cost data in provision systems had an would important impact on their decisions cost~~
65 ~~awareness levels.~~
- 66 • ~~Cost awareness training and inclusion of the cost approximation in ordering systems~~
67 ~~contribute to The key to reducing information asymmetry in hospitals is to provide training~~
68 ~~and include cost approximation in ordering systems.~~

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69 **1. Introduction**

70
71 Information asymmetry is one of the key features that distinguishes healthcare from a traditional
72 market economy that assumes all parties have access to perfect information [1, 2]. In healthcare,
73 service users lack the medical knowledge that healthcare professionals possess, and this causes
74 information asymmetry. Due to this imbalance of information, patients require health professionals
75 to act in their best interests without any conflict. This is a typical example of the agency relationship.
76 The principal-agent problem arises when there is a conflict of interest between the healthcare user
77 and the clinician [3, 4]. In most countries, healthcare services are regulated by governments and
78 financed by public funds fully or partially in order to prevent this problem.

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

90 Some studies have shown that clinicians acknowledge preventing unnecessary resource use as part of
91 their responsibility [9, 10]. However, the existing evidence suggests there are low levels of cost
92 awareness amongst clinicians. One systematic review revealed that only 33% of doctors provided an

93 estimate within 20% or 25% of the actual diagnostic costs [11]. This figure was only 16% for
94 consumables and medications in a national survey of 139 UK urologists [12]. There is limited evidence
95 on the factors contributing to the lack of cost awareness. In a large study, that included 2,556
96 physicians and 3,395 medical students from the USA, medical student respondents were more likely
97 than the qualified doctors to agree that the cost to society should be considered in treatment decisions
98 [13]. However, it is difficult to generalise these results to other settings.

99 The Good Stewardship Working Group identified the top five primary care procedures which are
100 overused and the cost of these procedures was estimated at \$5.8 billion per year in the US in 2011
101 [14, 15]. Increasing financial constraints and the COVID-19 pandemic have elevated the need to
102 provide cost-conscious care globally. This study aimed to explore cost awareness amongst clinicians
103 practising in the UK, US, Australia, New Zealand, and Spain. A secondary aim was to explore the
104 differences in cost awareness based on speciality, country and clinician seniority and to explore the
105 relationship between reported importance of cost and cost awareness. This study is the first step in
106 an investigation of what factors are associated with greater awareness of costs in different countries,
107 to ultimately inform strategies to improve clinician awareness of costs.

108 2. Methods

109

110 2.1. Study design and respondents

111

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

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Commented [A8]: Please specify how they were randomly selected.

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Commented [A10]: Please specify which country had two hospitals in the study.

Commented [A11]: Please specify when the survey was conducted.

127 2.2. Outcomes and analysis
128

129 The knowledge of cost was used as an indicator of cost-awareness in this study. Actual costs were
130 requested from the finance departments of each hospital site (Australia, New Zealand, Spain and USA)
131 or obtained from national published sources (UK). The financial departments requested the cost
132 information kept confidential since they were actual costs rather than prices. The main outcome was
133 the differential between the perceived and actual cost. To address any exchange rate issues we chose
134 to reflect this variability using (1) the ratio of estimated costs to actual costs, such that a number
135 greater (less) than 1 reflects over (under) estimation, and (2) whether the estimated costs were within
136 $\pm 25\%$ of the actual cost for each item ('costs in range', CIR). The ratio and proportion of CIR are
137 reported for each resource item, and compared across country, current role (qualified vs. student),
138 clinical specialty, availability of cost approximation in ordering systems and perceived importance of
139 cost. Significant differences across these categories were identified using the F-test to compare means
140 (for the ratio) and chi-squared test of independence (for $\pm 25\%$). We also used multivariate regression
141 analysis (ordinary least squares and logistic) to explore if certain respondent characteristics played a
142 greater or lesser role than others in determining the variation between estimated and actual cost.

143 3. Results
144

145 3.1. Respondent characteristics and perceptions on cost awareness
146

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

152 Although only 23% of the clinicians had access to an ordering system which provided cost
153 approximation, 74% of the respondents felt that having cost approximation as part of the ordering
154 system would impact on their decision-making. While 79.4% of respondents without access to cost
155 approximations felt that the system would be impactful, of those with access only 60% felt it
156 influenced their decisions. With respect to the importance of costs, for non-urgent tests 84% of the
157 respondents thought it was important (40% very important), while for urgent tests this value was 40%

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158 (10%). Around half of the respondents felt that they had received adequate training while 36% did
159 not.¹

160 3.2. Cost awareness amongst clinicians 161

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

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

175

176 3.3. Factors that affect cost awareness 177

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

180 The country of practice is significantly correlated with cost awareness levels for all items. Overall cost
181 awareness was highest in hospitals in Oceanic countries with overall CIR rates of ~~23~~4% and 26% in
182 Australia and New Zealand, respectively. However, even these hospitals had relatively low CIR rates,
183 at most 35% for the best-estimated cost, a unit of red blood cells (Table 3b). In keeping with this, the
184 mean estimate:actual cost ratio for Australia and New Zealand was 1.39 (SD 1.31) and 0.86 (SD 0.61),
185 respectively. In comparison, the hospital in the USA showed much less accurate estimates with an 3%
186 CIR rate and an overall cost estimate ratio of 0.28 (SD 0.25). Interestingly, Australia was the only
187 country to overestimate costs overall (mean cost estimate ratio 1.39) while all other countries
188 underestimated with ratios ranging from 0.28 to 0.86.

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

189 In terms of the qualifications and characteristics of respondents, current role (studying or practicing)
190 and primary area of expertise were related with similar margins of accuracy (Table 3b). While
191 anaesthetists had the lowest extent of overestimation (overall ratio 2.18), they were also the least
192 likely to accurately estimate a cost (12.8% CIR rate, overall), while surgeons and medical clinicians
193 overestimated the most (ratio 4.37 and 4.66, respectively) they were more likely to have an in-range
194 cost estimate. Although students tended to overestimate the cost to a greater extent than clinicians
195 (overall ratio 3.88 vs. 3.52), this difference appeared to be driven by much lower estimates provided
196 by anaesthetic respondents (Table 3a). Experience in terms of years working (or studying) had little
197 impact on cost awareness. Provision of cost approximation information in the ordering system had
198 varying impacts for different items, and this also varied depending on whether considering the ratio
199 or the margin of accuracy. Overall, respondents who had access to cost approximations were slightly
200 more likely to estimate a CIR (15.4% vs. 12.9%) but these estimates were much higher (ratio 5.57 vs.
201 3.00). The perception of having adequate training in cost awareness did not have a significant
202 association with respondent responses.

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

218 **4. Discussion**

219

220 This study aimed to explore cost awareness amongst clinicians from five countries as an indicator of
221 information asymmetry in hospitals with respect to finances. The findings show that despite the
222 updates to medical training and international recognition of the importance of health economics, cost

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- Journal name
- Article title
- Author names
- Affiliation and e-mail address of the corresponding author
- Funding and conflicts of interest statements

223 awareness and general austerity, there is still a lack of awareness amongst clinicians. The respondents
224 substantially overestimated the cost of most items and underestimated the cost of two procedures
225 which were amongst the most expensive items in the survey.

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

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

246 *4.1. Study findings in the context of existing literature*

247

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

253 Previous studies have identified poor access to information on costs as a key reason behind low levels
254 of cost awareness [19]. It has been shown that clinicians change their decision-making when cost
255 information is available [20-24]. In line with this, 74% of the clinicians in this study thought that the

256 provision of cost approximation would impact on their decision making although access to cost
257 approximation does not appear to lead to cost awareness. Hence, efforts to improve cost awareness
258 in clinicians should not seek to replace point-of-ordering reminders and cost information..
259 Additionally, some costs were more accurately estimated by respondents from countries with low
260 rates of access to cost information when ordering, although the majority (90%) of respondents who
261 had access to cost information were working in the UK or Australia. Therefore, although cost
262 approximation is important other factors such as country of practice are more likely to contribute to
263 the international variability.

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

269 4.2. Strength and limitations

270
271 To the best of the authors' knowledge, this is the first cross-national survey of cost awareness amongst
272 physicians. The survey was performed face-to-face in a kiosk format ~~that led to very high levels of~~
273 ~~survey completion~~ and real time data capture removed the opportunity for respondents to look up or
274 research cost information. Respondent selection bias ~~should be considered given that was reduced as~~
275 ~~the data are representative of those who were approached (effectively an unselected cohort from the~~
276 ~~available clinical staff was included in the study.) rather than those who would have been willing to~~
277 ~~respond to a survey sent in a digital, or other, format.~~ However, it might be that those who
278 participated in the study were more interested in the topic and hence had a higher cost-awareness
279 than the non-respondents. The individuals performing the questionnaire approached staff at hospital
280 sites where staff from all specialities were mixed (i.e. canteens). The individuals performing the
281 questionnaire were junior members of staff who would not recognise the majority of staff they
282 approached. Hence, this sampling approach should generate a reasonably unbiased sample of the
283 staff population. Notably, the cost-awareness levels estimated in this study were much lower
284 (between 4% and 23%) than the estimates in previous studies (20%-33%), although the potential
285 impacts of this on the factors that affect cost-awareness is not known. The face-to-face element of
286 the study also permitted respondent questions and clarification to improve the data quality and
287 accuracy.

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Commented [A23]: Not if those who declined to participate were different. Please revise this sentence.

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

294 There is no standardised measure of cost awareness amongst clinicians. The survey asked about the
295 'cost entailed' and estimates of these were compared to actual costs. We employed the ratio of
296 estimated costs to the actual costs and the proportion of estimates within 25% of the actual costs
297 which is in line with previous published papers and avoids issues with the variation in item costs [12,
298 19]. Because of this variation in costs (a coronary angiogram is 1000 times more costly than the least
299 expensive item) the CIR and ratio estimates for the overall cost- were skewed towards the most
300 expensive item and these should be interpreted carefully. One solution to this would be to obtain the
301 frequency of these procedures over a period of time (or for a typical consultation/inpatient stay) and
302 this would allow researchers to calculate a weighted aggregate cost which could be compared across
303 respondents' characteristics.

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

315 *4.3. Implications*

316

317 The existing evidence suggests that reducing information asymmetry by increasing cost awareness
318 amongst clinicians would reduce unnecessary resource use [14, 27, 28]. In addition, during economic
319 evaluations that involve clinicians, a considerable amount of time is spent discussing the key tenants

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320 of health economics. Hence, increasing cost-awareness amongst clinicians would enable more
321 collaborative work and save time and effort.

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

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

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

342 5. Conclusion

343

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

350 Declarations

351 **Funding:** No funding was received for this study.

Commented [A26]: I don't think these strong statements are supported by your study. For example, there was only one [or two] hospitals per country. Moreover, at the end of the results section you state: "Interestingly, the regression analysis found that provision of cost information did not have any significant impact on the cost awareness levels."

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

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

355 **Code availability:** Not applicable

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

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

360 Consent to participate: All clinicians provided verbal consent.

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

364

365

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Consent to participate

Consent for publication (from patients/participants)

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	

370 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%

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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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