Failure to review STAT clinical laboratory requests and its economical impact

Enrique Rodriguez-Borja*, Celia Villalba-Martinez, Esther Barba-Serrano, Arturo Carratala-Calvo

Laboratory of Biochemistry, Hospital Clínico Universitario Valencia, Valencia, Spain

*Corresponding author: enrobor@yahoo.es

Abstract

Background: Failure to follow-up laboratory test results has been described as one of the major processes contributing to unsafe patient care. Currently, most of the laboratories do not know with certainty not only their rate of missed (or unreviewed) requests but the economical cost and impact that this issue implies. The aim of our study was to measure that rate and calculate the resulting costs.

Material and methods: In January 2015, we checked in our Laboratory Information Management System (LIMS) for every emergency request from 1st July 2011 to 30th June 2014, if they had been reviewed by any allowed user or not. 319,064 requests were ordered during that period of time. Results were expressed as "ordered requests", "missed requests" and its percentage. Additionally, total cost of missed requests was calculated in euros (€). "Non-productive days" were theorised (as the days producing requests that were not reviewed) based on these results.

Results: 7924 requests (2.5%) were never reviewed by clinicians. This represented a total cost of 203,039 € and 27 "non-productive" days in three years. Significant differences between inpatients, outpatients and emergency department as well as different emergencies units were found after application of statistical analysis.

Conclusions: In terms of resources, never reviewed or missed requests appear to be a not negligible problem for the clinical laboratory management. Electronic result delivery, with electronic endorsement to indicate follow-up of requests along with better systems of electronic requesting should be investigated as a way of improving patient outcomes and save unnecessary expenses.

Key words: quality indicators; health care; extra-analytical phase; total quality management; clinical laboratory information systems

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Introduction

Failure to follow-up laboratory test results or complete requests has been described one of the major processes contributing to unsafe patient care (1). Not only that this can lead to missed or delayed diagnosis but it has an adverse impact on patients outcomes followed by potential legal implications (2,3). In fact, some authors consider it a post-postanalytical error as a part of extra-analytical testing process (4,5).

Despite the fact that clinicians are concerned that the way they manage results is not systematic (6) and laboratories have been constantly improving this process through information technology implementation (making it easier and more accessible) (7), managing the follow-up of laboratory requests still remains a complex process, not well standardised (8).

The ongoing introduction of Computer Physician Order Entry (CPOE) systems that allow the ordering and reviewing of requests online with no paper use would provide an improvement in follow-up results and a decrease of results or requests being missed or unreviewed (9).

Surprisingly we find few studies that describe the extent of missed requests in a complete electronic management system context and they have shown mixed results due to the different methods used that prevent robust comparisons (10,11). In fact, in those studies the rate of missed requests was generally high and showed that the technolo-

gy improvement made the problem not only easier to measure but more explicit.

So, the introduction of CPOE systems has shown that the problem could be a major drawback in post-post-analytical phase. First of all, currently, most of the laboratories (even those using CPOE) don't know with certainty their rate of missed requests so they cannot solve the post-post analytical problem. And secondly, they are not able to calculate the economical impact of these unreviewed requests in order to know with assurance its extent. In fact, as far as we know, this issue has been barely quantified before.

The purpose of this study was first to measure, using a robust and automatic tool, the rate of not reviewed (or never reviewed) requests in our emergency laboratory (we will use the term "missed requests" interchangeably). And second, calculate the economical impact of these non reviewed requests. Our hypothesis was that unreviewed requests is not a negligible problem for the clinical laboratory management and represents an important expense in economical resources.

Materials and methods

Study design

This retrospective study was conducted in the Biochemistry Laboratory of Valencia´s Clinic Hospital. The centre serves around 370,000 people in Valencia´s metropolitan area. Four years ago, our Laboratory implemented a CPOE system directly linked to our Laboratory Information Management System (LIMS) not only for request but to review test reports or requests.

We have an emergency or STAT (short turnaround time) laboratory (biochemistry and haematology) separated from our main core lab. The general types of tests in this stat clinical laboratory include basic chemistry tests (glucose, electrolytes, AST, ALT, urea, creatinine, calcium, total proteins, bilirubin and amylase), haematology tests (full blood count), coagulation tests (PT, APTT, fibrinogen and D-dimer), some immunoassays (C-reactive protein, NT-ProBNP, procalcitonin, high sensitivity troponin–T and HCG), blood gas analysis, body fluid analysis and urine analysis. This laboratory provides a 24/7 service and receives approximately 300 emergency requests *per* day coming from three main origins: emergency department (ED) patients (facility specialised in emergency medicine that operates 24 hours a day without prior appointment), inpatients (hospital wards) and outpatients (specialist outpatients e.g. oncology, cardiology, endocrinology). We established a general maximum turnaround time (TAT) of one hour from the time the samples were received in the emergency laboratory to complete results were reported and available on our intranet. The choice of that particular TAT was agreed according to the necessities demanded by clinicians working in those units.

Methods

During the first week of January 2015, we studied (through an enquiry to our LIMS) every emergency request from 1st July 2011 to 30th June 2014 (36 months or 3 years), whether they had been reviewed by any clinician (or allowed user). We assumed that this enquiry was a specific record which certified that a clinician had accessed to patient´s data since we do not print any report in paper as well as we do not call results to the ED and other destinations (except critical results). 319,064 requests were ordered from 1st July 2011 to 30th June 2014 (291 requests *per* day).

Our LIMS was able to determine, through several Structured Query Language (SQL) sentences if a full request was reviewed or not by any allowed user (even different from the original requestor). We allowed a maximum time of 6 months for health care providers to review the requests. Any test result included in a not reviewed request was simply not reviewed except critical results. All the critical results were reported by phone call to our requestors regardless of being reviewed afterwards by clinicians of not. Requests with a phone reported critical result were excluded from the study because they were considered in some way "forcedly reviewed".

Results were expressed for each one of the three main origins (total and semi annually) as "ordered

requests", requests never reviewed or "missed requests" and percentage of missed requests or "% of missed requests". Data collected in semesters allowed us to detect any important seasonal variation and/or temporal evolution. Additionally, this enquiry could give us information about the total cost of all the missed tests included in these missed requests (according to Valencian Health Department Tax Law) in euros (€). Cost reflected in this Law incorporates not only reagents costs but instrumentation, labour costs and structural costs in each test. E.g. an unreviewed request including serum glucose, serum calcium, full blood count and troponin T would represent a total expense of 22.52 € due to the cost of each test reflected in Tax Law (serum glucose 0.6 € / test; serum calcium 0.68 € / test, full blood count 3.19 € / test and troponin T 18.05 € / test).

Having the total ordered (A) and missed (B) requests and the number of days for each semester or period of time (C), we calculated the number of days that were completely "non-productive" in our stat laboratory as the hypothetical days in each semester producing full requests/results that were not reviewed or followed up using the formula: ((B x C) / A). This indicator is an easy way to detect the impact of unreviewed requests in terms of "wasted" or "lost" laboratory working time. E.g. 10,000 ordered requests (A), 200 missed requests (B) and 181 working days in a particular semester. Non-productive days are calculated as follows ((200 x 181) / 10,000) = 3.62 or approximately 4 days in a semester.

Besides, for the emergency department requests specifically, we studied the rate of missed requests based on the requestor unit (general emergency unit, surgery & trauma, obstetrics, paediatrics and other minor emergency services). All data was retrieved directly from our LIMS (Gestlab ©, Cointec Spain).

Statistical analysis

For evaluating variations in percentages of missed requests between requestor origins and emergency department units, Pearson´s chi – squared test was applied. The values $P < 0.05$ were considered statistically significant. Statistical analysis was done using IBM SPSS 17.0 statistical software.

Results

319,064 requests were ordered from 1st July 2011 to 30th June 2014 (291 requests per day). From these, 7924 requests (2.5%) were never reviewed by clinicians. These missed requests represented a total cost of 203,039 € and 27 "non-productive" days in three years (a mean of 67,679.67 € and 9 "non-productive" days per year respectively) (Table 1 and 2).

The percentages of missed requests were 5.7% for outpatients, 3.1% for inpatients and 1.7% for emergency department. The difference between our three origins for these rates was statistically significant ($\chi^2 = 1144.96$; $P < 0.001$). However, the total cost of "missed" requests in three years was the highest for inpatients (111,730 €, more than half of the expense) followed by emergency department (78,832 €) and outpatients (19,927 €) due to their total activity and request cost.

As for the emergency department we found important variations in percentages of missed requests between the different units (Table 3). Again, the difference between them was statistically significant ($\chi^2 = 1076.97$; $P < 0.001$). Paediatrics had a very low percentage of missed requests (0.7%) followed by general emergency unit (1.4%). On the other hand, obstetrics had the highest percentage (5.9%).

Discussion

As far as we know, our study period of time is the largest that we have found in the literature (three years and more than 300,000 requests included) regarding clinical laboratory missed requests. We have obtained a total rate of unreviewed emergency requests of 2.5%. This amount has represented an expense of 203,039 € and 27 non-productive days in three years.

Our retrospective study showed that the vast majority of STAT laboratory requests were followed up by physicians. The percentages of missed requests in our case (2.5%) are, by far, less than those reported by other older studies using paper ordering and reporting systems. Stiell et al. reported missing information in 23.3% of laboratory test re-

Table 1. Ordered requests (N) / Missed requests (N) / Missed requests (%) by origin and "Non-productive" days (2nd Semester 2011 – 1st Semester 2014).

	2nd Semester 2011	1st Semester 2012	2nd Semester 2012	1st Semester 2013	2nd Semester 2013	1st Semester 2014	TOTAL	TOTAL (per year)
Emergency Requests: Ordered (N) / Missed (N) / Missed (%)	29,599 / 670 / 2.3	28,489 / 579 / 2.0	27,565 / 474 / 1.7	27,739 / 369 / 1.3	28,262 / 419 / 1.5	28,494 / 439 / 1.5	170,148 / 2950 / 1.7	56,716 / 983 / 1.7
Inpatient Requests: Ordered (N) / Missed (N) / Missed (%)	21,159 / 742 / 3.5	23,446 / 810 / 3.5	21,646 / 601 / 2.8	23,064 / 672 / 2.9	22,799 / 726 / 3.2	24,395 / 711 / 2.9	136,509 / 4262 / 3.1	45,503 / 1421 / 3.1
Outpatients Requests: Ordered (N) / Missed (N) / Missed (%)	1932 / 110 / 5.7	2053 / 92 / 4.5	2156 / 105 / 4.9	2205 / 112 / 5.1	2010 / 134 / 6.7	2051 / 159 / 7.8	12,407 / 712 / 5.7	4136 / 237 / 5.7
TOTAL Requests Ordered (N) / Missed (N) / Missed (%)	52,690 / 1522 / 2.9	52,988 / 1481 / 2.7	51,367 / 1180 / 2.3	53,008 / 1153 / 2.2	53,071 / 1279 / 2.4	54,940 / 1309 / 2.4	319,064 / 7924 / 2.5	106,355 / 2641 / 2.5
"Non-productive" days	5	5	4	4	4	4	27	9

Table 2. Resulting Costs (€) by Origin (2nd Semester 2011 – 1st Semester 2014).

	2nd Semester 2011	1st Semester 2012	2nd Semester 2012	1st Semester 2013	2nd Semester 2013	1st Semester 2014	TOTAL	TOTAL (per year)
Emergency missed requests costs	17,416 €	17,282 €	14,219 €	9335 €	9676 €	10,454 €	78,382 €	26,127 €
Inpatient missed requests costs	20,776 €	22,235 €	16,497 €	16,879 €	18,236 €	17,107 €	111,730 €	37,243 €
Outpatients missed requests costs	2526 €	1892 €	2160 €	1843 €	2205 €	2301 €	12,927 €	4309 €
Total missed requests costs	40,718 €	41,409 €	32,876 €	28,057 €	30,117 €	29,862 €	203,039 €	67,679 €

quests (12) while Kilpatrick and Holding showed that 45% of the requests from accident and emergency department were never viewed on a terminal (13). Other authors have suggested that a CPOE system assists in reducing the risk of missed test results. Callen *et al.* stablished a couple of days the length of the window that was allowed for the health care providers to evaluate the patient emergency requests and they obtained lower results of missed requests (14). Our results are more in accordance with these newer studies using CPOE systems environment despite the fact that not only our requests come for clinical biochemistry and haematology laboratory instead of microbiology or radiology but there are differences in the length of the window used in each study. It seems paradoxical to find slightly higher results of unreviewed requests having a wider length of the window as in our case. We can affirm that is difficult to compare the few studies regarding this subject

Table 3. Ordered requests, missed requests and percentage of missed requests (%) by emergency department unit.

	Ordered requests (N)	Missed requests (N)	Missed requests (%)
Surgery + trauma	19,478	654	3.4
Obstetrics	1941	115	5.9
General emergencies	135,099	1831	1.4
Paediatrics	8547	60	0.7
Other minor services	1201	59	4.9
Total	170,148	2950	1.7

when it is not well described the length of the window provided and the type and number of requests analysed.

Even though total missed requests costs shows a decreasing trend (Table 2), this economical evolution is more related to a global decrease in general costs produced by implementation of several management rules through CPOE in the last two years (data not shown), specially in emergency department, rather than a real trend of improving requests enquiry by clinicians. In fact percentages of missed requests remain quite similar along the time frame (Table 1).

In our particular case, the evolution of percentage of missed requests along the period of study is roughly constant with a downward trend except for outpatients requests where we can identify a clear ascending pattern and a higher rate compared with inpatients or emergency department. Maybe these particular outpatient requests were not so urgent or necessary when it came to taking clinical decisions and/or clinicians forgot they were ordered after medical consultation. Fortunately they represent only a 10% of the total missed requests.

We have detected important and significant variations in the percentage of missed requests not only between the different origins but the different emergency units as well. Paediatrics and general emergency unit showed a very low percentage of unreviewed requests. We can conclude that in these units, professionals are really concerned with laboratory results when it comes to taking clinical decisions. Those percentages were higher in obstetrics and surgery and trauma units. We presume most of this missed requests were part of internal protocols and they are only reviewed just in case of surgical or postpartum complications.

Regarding total costs, we observe a global reduction pattern but, as we have explained before, it is more related with the implementation of several management rules through CPOE in the last two years that have saved expenses. Inpatients missed requests represent more than a half of the expense being Inpatients percentage of missed requests nearly twice emergency department (3.1% *vs*. 1.7%).

However there are two important limitations of our study. We have not studied the impact of these missed requests on patient outcomes and even in the reviewed requests we have not followed up if the subsequent clinical actions, if necessary, were correct (or made). Our study is not focused in the clinical part of this substantial issue or in the safety implications but in the economical impact that it has. Maybe a 2.5% of emergency missed requests is unimportant (in relative terms), but in absolute terms (2641 missed requests per year and nearly 68,000 € / year of expense) we consider we must stand back and take a look at a problem that could be even bigger than we expected. Our emergency lab only represents a 20% of our total activity (number of requests) and a 10% of our costs in € (data not shown). If we assumed a similar rate of missing requests in our core lab we would have around 13,000 non reviewed requests per year and more than 600,000 € / year of expense.

So, were those emergency requests really that important for clinicians in the first place or just a failure to follow-up results that could have a negative impact on patient outcomes? In the case they were not so urgent or necessary (our main suspicion due to our general very low rate of missing requests), we could theorise that there have been 9 out of 365 days in our emergency laboratory that have been worked needlessly for nobody. That is more than an entire week at full performance. In a laboratory like ours, 68,000 € / year would allow us

to hire more staff (e.g. 3 medical laboratory assistants full time) that could help in other areas.

However, the existence of a failure to follow-up results and impact on patient outcomes is infinitely more serious. There is enormous variability reported on the extent of the problem and the few studies that have quantified it don´t offer a comparable rate. Even if only 1% of our patients would be affected in their safety by a missed request (a very optimistic approach), it would represent around 26 patients *per* year.

It is obvious that we must act in both directions and interventions might need to target not only individual providers but organisational factors (15). On one side, the economical issue, avoiding unnecessary requests and tests before they reach the laboratory through educational interventions, specialty/staff grade limitations, guideline and protocol development, feedback on test usage and cost: in a word, developing a powerful CPOE system in order to changing incorrect requesting behaviour (16). Even though evidence supporting a direct improvement in patient outcome is not abundant, it is difficult to argue that it will not improve the quality of requesting.

In addition to this, new information technology need to be developed in order to reduce errors in follow up requests and improve patient safety, given the volume of information that clinicians both generate and review (17,18). Recently, Georgiou *et al.* have proposed the implementation of an interesting electronic endorsement of the results by the physicians that could act as a safety net to ensure follow-up (19), while others authors have discussed the idea of implement the concept of "Enquiry time" in LIMS (as the time between validation of the results and the first review made by an allowed user via electronic medical record) as a tool that could evaluate turnaround times in the post-post-analytical phase detecting and avoiding missing results (20,21).

Conclusion

In terms of resources, never reviewed or missed requests appear to be a not negligible problem for the clinical laboratory management. Apart from the potential to compromise patient care, they involve a considerable expense for the laboratory even though finding low rates. The wasted money and resources mean an important lack of effectiveness in lab management and by extension, for the quality of patient care (22). In addition to improve CPOE systems, laboratories should be able to detect missed requests at any level. We encouraged new LIMS and medical software developers to implement this function in their products.

Potential conflict of interest

None declared.

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