Research Article

Hilal Aksoy*, Abdullah Ozturk, Dilek Tarhan, Ibrahim Dolukup and Duygu Ayhan Baser

Biochemistry laboratory errors and patient safety: Turkey data

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Abstract

Objectives: Our aim in this study is to provide information about the rate of errors in the process of the biochemistry laboratories in the hospitals in Turkey with the “Indicators”.

Methods: The hospitals calculate their own data according to the indicator cards defined by the Ministry of Health of Turkey and enter into the system once in a year. In this study we examined the quality indicators related to the disruptions in the biochemistry laboratory of hospitals for the year of 2018.

Results: All indicators except “Non-timely reported result rate in biochemistry laboratory” are found to be significantly higher in university hospitals. This indicator is found to be significantly higher in private hospitals (p: 0.030) “Lost sample rate in biochemistry laboratory” is found to be significantly higher in Eastern Anatolia Region (p: 0.000) and “Non-timely reported result rate in biochemistry laboratory” is found to be significantly higher in Aegean Region (p: 0.008).

Conclusions: The ratio of non-timely reported result rate is the most seen disruption in biochemistry laboratories. It may be due to lots of reasons; lack of biochemistry equipment, lack of staff, problems in transportation, etc. The management of hospitals and the staff should take measures and regulations about problems.

Keywords: biochemistry; hospitals; laboratories; medical error; quality control.

Introduction

The error is a planned series of mental or physical activities cannot achieve the desired goal and result [1]. The Institute of Medicine defines the medical error as “a planned action does not result in its intended purpose or the usage of a wrong plan to achieve a goal” [2, 3].

All errors in healthcare delivery can lead to adverse events and injuries, regardless of patients’ underlying conditions [4].

The studies have reported that 10% of hospitalized patients are affected by medical errors [5, 6] and 61% of the side effects caused by the human factor could be prevented [7].

Reducing errors and increasing patient safety are the most important parts of healthcare service quality [8]. Any mistake made in healthcare can threaten human health. For this reason, zero error should be targeted. Laboratories are the important parts of the healthcare system. An error made in a laboratory may cause complete change of diagnosis and treatment process and harm that patient. Therefore, the quality of service should be kept at the highest level. In “Healthcare Quality Standards (HQS) Hospital” set, the standards related to the Biochemistry laboratories are specified in Table 1. The Department of Healthcare Quality, Accreditation and Employee Rights organized expert groups and these standards were prepared with the participation of experts in their field. Five of them are the basic standards and are as follows:

- Pre-analytical process regarding biochemistry laboratory tests should be kept under control.
- Processes for the acceptance of samples to the laboratory and preparation for analysis should be checked.
Internal quality control studies for laboratory tests should be conducted.
External quality assessment studies should be conducted for laboratory tests.
Timely and effective notification of critical values should be ensured [9].

These 5 standards are indispensable. Basic standards are also important in scoring the Hospital Quality Score. Hospital Quality Score 5 for each basic standard not met point are reduced. If the number of basic standards not met is six or above, the Hospital Quality Score will be reduced by 30 points.

If laboratory errors are classified simply, they occur in pre-analytical, analytical and postanalytical phases. Pre-analytical phase: is a stage before the test, outside the laboratory and until the analysis in the laboratory. Analytical phase: is a stage which the test or measurement is made. The postanalytical phase is a stage where the test result is transferred to a patient’s test report and clinician making the request using a patient’s test result for the benefit of patient or individual [10–12]. The studies showed that the vast majority of the laboratory errors occur in the pre-analytical and postanalytical phases [13]. pre-analytical errors are generally observed at a higher rate. Because the process is generally not managed by the medical laboratory and the laboratory can intervene in the preanalytic process only when it reaches the sample laboratory limits [14]. It is equally important to measure and evaluate the effectiveness of every service that forms part of this system, as well as the establishment of a modern healthcare system focused on providing qualified health care services. Surely, each system must firstly collect information about the activities it performs in order to determine the extent to which its service achieves its purpose. In other words, it should make measurements, try to reach some results and decisions by making use of measurement results and use these results as a guide for future studies. Accordingly, “Indicators” have been created in order to measure service processes and effectiveness of the service in health institutions. The indicator card defines the indicator name, indicator code, and definition and calculation method. Also these indicators were prepared with the participation of experts in their field too. The indicators created for the “Biochemistry Laboratory” in the “Indicator Management Guide” are as follow [15]:

- GBBL01 Rejected sample rate in biochemistry laboratory tests
- GBBL02 Lost sample rate in the biochemistry laboratory
- GBBL03 The number of the nonconformities in the biochemistry laboratory internal quality control studies
- GBBL04 The number of the nonconformities in the biochemistry laboratory external quality control studies
- GBBL05 Non-timely reported result rate in biochemistry laboratory (see Table 2)

Our purpose in this study is to provide information about the rate of errors in the process of the biochemistry laboratories in the hospitals in Turkey with the “Indicators”.

### Materials and methods

The approval for the study was obtained from the Republic of Turkey, Ministry of Health General Directorate of Health Services, Department of Healthcare Quality, Accreditation and Employee Rights.

<table>
<thead>
<tr>
<th>Table 1: HQS – the hospital biochemistry laboratory standards.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SBL01</strong></td>
</tr>
<tr>
<td><strong>SBL02</strong></td>
</tr>
<tr>
<td><strong>SBL03</strong></td>
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<tr>
<td><strong>SBL04</strong></td>
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<td><strong>SBL05</strong></td>
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<td><strong>SBL06</strong></td>
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<td><strong>SBL07</strong></td>
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<td><strong>SBL08</strong></td>
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<td><strong>SBL09</strong></td>
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<td><strong>SBL10</strong></td>
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<td><strong>SBL11</strong></td>
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<tr>
<td><strong>SBL12</strong></td>
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<tr>
<td><strong>SBL13</strong></td>
</tr>
<tr>
<td><strong>SBL14</strong></td>
</tr>
<tr>
<td><strong>SBL15</strong></td>
</tr>
</tbody>
</table>

*The bold written standards are basic standards.*The italic written standards are optional standard.
TUR-GOS (Turkey Healthcare Quality Indicators System) is an indicator management system designed to evaluate the quality of health service, developed by the Republic of Turkey, Ministry of Health. The hospitals calculate their data according to the indicator cards determined by the Ministry of Health. Then the results are entered into the system and sent to the Ministry once a year.

In this study, the negativities that occurred in the biochemistry laboratories of the hospitals in 2018 were evaluated using the TUR-GOS data. The evaluated indicators are:

- **Rejected sample rate in biochemistry laboratory tests**: GBBL01 Rejected sample rate in biochemistry Laboratory tests

- **Lost sample rate in biochemistry laboratory**: GBBL02 Lost sample rate in biochemistry laboratory

- **Number of nonconformities in biochemistry Laboratory internal quality control studies**: GBBL03 The number of the nonconformities in the biochemistry laboratory internal quality control studies

- **Number of nonconformities in biochemistry Laboratory external quality control studies**: GBBL04 The number of the nonconformities in the biochemistry laboratory external quality control studies

- **Non-timely reported result rate in biochemistry Laboratory**: GBBL05 Non-timely reported result rate

The results were presented on the average on the basis of public, private and university hospitals’ data. Also the hospitals were classified due to geographic regions and the indicators results’ were compared due to geographic regions.

Statistical evaluation was performed using the SPSS (Statistical Packet for the Social Science) 23.0 package program. In the evaluation of the data obtained; continuous variables in the study were expressed as mean ± standard deviation or median (minimum-maximum) values. Kruskal Wallis test was used for intergroup comparisons of these parameters. Comparison of categorical variables was made using the chi-square test. p<0.05 was considered as statistically significant.

**Results**

The number of the hospitals that sent data for each indicator is as follows:

- **Rejected sample rate in biochemistry laboratory tests** (GBBL01): 1,115 (State hospitals: 595, Private hospitals: 398, University hospitals: 122).

- **Lost sample rate in biochemistry laboratory** (GBBL02): 1,111 (State hospitals: 594, Private hospitals: 398, University hospitals: 119).

- **Number of nonconformities in biochemistry Laboratory internal quality control studies** (GBBL03): 1,096 (State hospitals: 591, Private hospitals: 385, University hospitals: 120).

- **Number of nonconformities in biochemistry Laboratory external quality control studies** (GBBL04): 1,114 (State hospitals: 594, Private hospitals: 398, University hospitals: 119).

- **Non-timely reported result rate in biochemistry Laboratory** (GBBL05): 1,096 (State hospitals: 591, Private hospitals: 385, University hospitals: 120).
Table 3: The indicator rates by hospitals.

<table>
<thead>
<tr>
<th>Indicator parameters</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STATE HOSPITALS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of samples rejected</td>
<td>595</td>
<td>1,410.0975</td>
<td>2,842.29759</td>
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<td>36,572.00</td>
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<tr>
<td>Total number of samples sent to the laboratory</td>
<td>595</td>
<td>322,384.4992</td>
<td>1,072,597.42383</td>
<td>0.00</td>
<td>21,323,820.00</td>
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<tr>
<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>562</td>
<td>0.6270</td>
<td>1.14793</td>
<td>0.00</td>
<td>20.69</td>
</tr>
<tr>
<td>Number of lost samples</td>
<td>594</td>
<td>274.6380</td>
<td>3,930.30580</td>
<td>0.00</td>
<td>86,108.00</td>
</tr>
<tr>
<td>Total number of samples taken</td>
<td>594</td>
<td>285,336.9562</td>
<td>631,425.50046</td>
<td>0.00</td>
<td>11,550,835.00</td>
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<tr>
<td>Sample rate lost in biochemistry laboratory</td>
<td>554</td>
<td>0.0526</td>
<td>0.36332</td>
<td>0.00</td>
<td>7.28</td>
</tr>
<tr>
<td>Number of results not delivered on time</td>
<td>589</td>
<td>13,326.4822</td>
<td>57,486.70947</td>
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<td>873,157.00</td>
</tr>
<tr>
<td>Total number of results given</td>
<td>589</td>
<td>677,780.2513</td>
<td>1,671,521.28489</td>
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<td>21,322,435.00</td>
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<tr>
<td>Non-timely reported result rate</td>
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<td>2.0375</td>
<td>3.39085</td>
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<td>26.16</td>
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<td>Number of nonconformities in external quality control studies</td>
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<td>55.6956</td>
<td>853.51949</td>
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<td>591</td>
<td>629.5854</td>
<td>3,780.07144</td>
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<td>81,747.00</td>
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<tr>
<td><strong>PRIVATE HOSPITALS</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of samples rejected</td>
<td>398</td>
<td>484.4849</td>
<td>877.91960</td>
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<td>8,144.00</td>
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<td>Total number of samples sent to the laboratory</td>
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<td>811,118.57791</td>
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<td>15,323,925.00</td>
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<tr>
<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>353</td>
<td>0.4625</td>
<td>0.60787</td>
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<td>3.95</td>
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<tr>
<td>Number of lost samples</td>
<td>398</td>
<td>13.2764</td>
<td>197.87501</td>
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<td>3,723.00</td>
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<tr>
<td>Total number of samples taken</td>
<td>398</td>
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<tr>
<td>Sample rate lost in biochemistry laboratory</td>
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<td>0.06647</td>
<td>0.00</td>
<td>1.18</td>
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<tr>
<td>Number of results not delivered on time</td>
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<td>8,984.3989</td>
<td>33,675.48312</td>
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<td>338,542.00</td>
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<td>Total number of results given</td>
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<td>15,323,925.00</td>
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<tr>
<td>Non-timely reported result rate</td>
<td>346</td>
<td>3.2365</td>
<td>12.74210</td>
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<td>205.00</td>
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<tr>
<td>Number of nonconformities in external quality control studies</td>
<td>387</td>
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<td>228.00</td>
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<td>Number of nonconformities in internal quality control studies</td>
<td>385</td>
<td>360.4390</td>
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<td>26,520.00</td>
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<td><strong>UNIVERSITY HOSPITALS</strong></td>
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<tr>
<td>Number of samples rejected</td>
<td>122</td>
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<td>12,672.09926</td>
<td>0.00</td>
<td>86,368.00</td>
</tr>
<tr>
<td>Total number of samples sent to the laboratory</td>
<td>122</td>
<td>1,142,759.3197</td>
<td>1,347,988.01680</td>
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<td>7,694,690.00</td>
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<td>114</td>
<td>1.0990</td>
<td>1.41120</td>
<td>0.01</td>
<td>11.48</td>
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<tr>
<td>Number of lost samples</td>
<td>119</td>
<td>837.7479</td>
<td>6,286.09682</td>
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<td>65,202.00</td>
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<td>Total number of samples taken</td>
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<td>995,003.0588</td>
<td>1,064,026.25924</td>
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<td>5,716,137.00</td>
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<tr>
<td>Sample rate Lost in biochemistry laboratory</td>
<td>110</td>
<td>0.0612</td>
<td>0.24630</td>
<td>0.00</td>
<td>1.76</td>
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<tr>
<td>Number of results not delivered on time</td>
<td>121</td>
<td>50,595.3388</td>
<td>132,037.69521</td>
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<td>1,055,662.00</td>
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<tr>
<td>Total number of results given</td>
<td>121</td>
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<td>2,241,555.87662</td>
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<td>10,048,591.00</td>
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<td>Non-timely reported result rate</td>
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<td>3.0502</td>
<td>5.34272</td>
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<td>56.4750</td>
<td>120.41043</td>
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<tr>
<td>Number of nonconformities in internal quality control studies</td>
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<td>1886.7000</td>
<td>6,672.86414</td>
<td>0.00</td>
<td>57,653.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of samples rejected</td>
<td>1,115</td>
<td>1973.8126</td>
<td>5,415.28375</td>
<td>0.00</td>
<td>86,368.00</td>
</tr>
<tr>
<td>Total number of samples sent to the laboratory</td>
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<td>369,804.8287</td>
<td>1,059,129.15856</td>
<td>0.00</td>
<td>21,323,820.00</td>
</tr>
<tr>
<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>1,029</td>
<td>0.6229</td>
<td>1.04811</td>
<td>0.00</td>
<td>20.69</td>
</tr>
<tr>
<td>Number of lost samples</td>
<td>1,111</td>
<td>241.3240</td>
<td>3,539.00471</td>
<td>0.00</td>
<td>86,108.00</td>
</tr>
<tr>
<td>Total number of samples taken</td>
<td>1,111</td>
<td>343,389.2502</td>
<td>1,096,320.89744</td>
<td>0.00</td>
<td>29,786,225.00</td>
</tr>
<tr>
<td>Sample rate Lost in biochemistry laboratory</td>
<td>1,012</td>
<td>0.0375</td>
<td>0.28423</td>
<td>0.00</td>
<td>7.28</td>
</tr>
<tr>
<td>Number of results not delivered on time</td>
<td>1,102</td>
<td>15,874.0639</td>
<td>64,966.72270</td>
<td>0.00</td>
<td>1,055,662.00</td>
</tr>
<tr>
<td>Total number of results given</td>
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<td>689,432.3848</td>
<td>1,602,888.03590</td>
<td>0.00</td>
<td>21,322,435.00</td>
</tr>
<tr>
<td>Non-timely reported result rate</td>
<td>1,008</td>
<td>2.5596</td>
<td>8.08328</td>
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<td>205.00</td>
</tr>
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<td>Number of nonconformities in external quality control studies</td>
<td>1,095</td>
<td>39.0849</td>
<td>626.98474</td>
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<tr>
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<td>672.6807</td>
<td>3,766.73910</td>
<td>0.00</td>
<td>81,747.00</td>
</tr>
</tbody>
</table>
The number of the nonconformities in the biochemistry laboratory external quality control studies (GBBL04): 1,095 (State hospitals: 588, Private hospitals: 387, University hospitals: 120).

Non-timely reported result rate in biochemistry laboratory (GBBL05): 1,102 (State hospitals: 589, Private hospitals: 392, University hospitals: 121).

The mean value of the rejected sample rate in biochemistry laboratory tests in the state hospitals: 0.6270%, in the private hospitals: 0.4625% and in the university hospitals: 1.0990%.

The mean value of the lost sample rate in the biochemistry laboratory in the state hospitals: 0.526%, in the private hospitals: 0.0060% and in the university hospitals: 0.612%.

The mean value of the number of the nonconformities in the biochemistry laboratory internal quality control studies in the state hospitals: 629.5854, in the private hospitals: 360.4390, and in the university hospitals: 1886.70.

The mean value of the number of the nonconformities in the biochemistry laboratory external quality control studies in the state hospitals: 55.6956, in the private hospitals: 8.4548 and in the university hospitals: 56.475.

The mean value of the non-timely reported result rate in the biochemistry laboratory, in the state hospitals: 2.0375%, in the private hospitals: 3.2365%, and in the university hospitals: 56.475.

The mean value of the number of the nonconformities in the biochemistry laboratory external quality control studies in the state hospitals: 3.0502% (see Table 3).

All indicators except GBBL05 are found to be significantly higher in university hospitals. GBBL05 is found to be significantly higher in private hospitals (p:0.030) (see Table 4).

While the most data were sent by the hospitals in the Marmara region, the least data were sent by the hospitals in the Eastern Anatolia and Southeastern Anatolia region (see Table 5). GBBL02 is found to be significantly higher in Eastern Anatolia Region (p:0.000) and GBBL05 is found to be significantly higher in Aegean Region (p:0.008) (see Table 6).

**Discussion**

Errors in biochemistry laboratories in the hospitals in our country are coded with the error classification systems according to the Security Reporting System (SRS) infrastructure. Since most of the laboratory information systems are integrated with SRS, all error applications are sent directly to the national system. Unlike analytical and postanalytical processes, the pre-analytical process covers a large number of units that are difficult to keep under control by the laboratory team in the healthcare facilities such as clinics, emergency services, polyclinics. Therefore, the error rate may be higher in the pre-analytical phase. In the studies conducted, it was reported that the errors were made in the pre-analytical phase, and the second most errors were made in the postanalytical phase [13, 14]. However, in our study, the “non-timely reported result rate in biochemistry laboratory” belonging to the post-analytical phase was higher. The analytical process errors were found to be low in accordance with the literature.

In the study carried out by Oz et al. in Kayseri Training and Research Hospital, sample rejection rates were 0.6% for hematological tests and 0.3% for biochemical tests [16]. In the study carried out by Ozcan et al. in Corum State Hospital, the frequency of preanalytic error was stated as 0.77% [17].

In another study conducted in a state hospital in Ankara, 0.81% of the samples sent to the central laboratory and 0.69% of the samples sent to the emergency laboratory were rejected [18]. The results are consistent with our study data. In the studies, the most common causes of preanalytical errors were clotted sample, insufficient sampling and contamination [16–18].

In the study conducted with 30 health institutions in the USA, pre-analytical laboratory errors were reported as the most common errors with 81.1%. Among these errors, the most common errors are those that arise from not labeling the sample taken, incorrect labeling of the sample.

**Table 4:** Comparison of indicators by hospital types Kruskal-Wallis Test.

<table>
<thead>
<tr>
<th>Test statisticsa,b</th>
<th>Chi-square</th>
<th>df</th>
<th>Asymp. Sig.</th>
</tr>
</thead>
<tbody>
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<td>2</td>
<td>0.000</td>
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<tr>
<td>Total number of samples sent to the laboratory</td>
<td>146.760</td>
<td>2</td>
<td>0.000</td>
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<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>70.729</td>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td>Number of lost samples</td>
<td>56.131</td>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td>Total number of samples taken</td>
<td>132.316</td>
<td>2</td>
<td>0.000</td>
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<tr>
<td>Sample rate lost in biochemistry laboratory</td>
<td>45.663</td>
<td>2</td>
<td>0.000</td>
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<tr>
<td>Number of results not delivered on time</td>
<td>39.221</td>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td>Total number of results given</td>
<td>93.907</td>
<td>2</td>
<td>0.000</td>
</tr>
<tr>
<td>Non-timely reported result rate</td>
<td>6.984</td>
<td>2</td>
<td>0.030</td>
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<tr>
<td>Number of nonconformities in external quality control studies</td>
<td>91.225</td>
<td>2</td>
<td>0.000</td>
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<tr>
<td>Number of nonconformities in internal quality control studies</td>
<td>14.450</td>
<td>2</td>
<td>0.001</td>
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</tbody>
</table>

aKruskal Wallis Test. bGrouping Variable: Hospital type. The significance level based on the asymptotic distribution of a test statistic. Typically, a value of less than 0.05 is considered significant. The asymptotic significance is based on the assumption that the data set is large. If the data set is small or poorly distributed, this may not be a good indication of significance.
Table 5: The indicators by geographic regions.

<table>
<thead>
<tr>
<th>Geographic region</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aegean region</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Number of samples rejected</td>
<td>151</td>
<td>1791.5166</td>
<td>3,903.09858</td>
<td>0.00</td>
<td>24,670.00</td>
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<tr>
<td>Total number of samples sent to the laboratory</td>
<td>151</td>
<td>309,218.1258</td>
<td>390,762.28971</td>
<td>0.00</td>
<td>1,977,014.00</td>
</tr>
<tr>
<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>138</td>
<td>0.5174</td>
<td>0.54498</td>
<td>0.00</td>
<td>3.13</td>
</tr>
<tr>
<td>Number of lost samples</td>
<td>150</td>
<td>580.3533</td>
<td>7,030.25817</td>
<td>0.00</td>
<td>86,108.00</td>
</tr>
<tr>
<td>Total number of samples taken</td>
<td>150</td>
<td>326,483.0600</td>
<td>459,036.59558</td>
<td>0.00</td>
<td>3,303,429.00</td>
</tr>
<tr>
<td>Sample rate lost in biochemistry laboratory</td>
<td>137</td>
<td>0.0103</td>
<td>0.07489</td>
<td>0.00</td>
<td>0.83</td>
</tr>
<tr>
<td>Number of results not delivered on time</td>
<td>146</td>
<td>21,898.6738</td>
<td>85,277.09047</td>
<td>0.00</td>
<td>705,185.00</td>
</tr>
<tr>
<td>Total number of results given</td>
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<td>631,513.9589</td>
<td>1,135,644.16782</td>
<td>0.00</td>
<td>8,955,186.00</td>
</tr>
<tr>
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<td>134</td>
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<td>18.75770</td>
<td>0.00</td>
<td>205.00</td>
</tr>
<tr>
<td>Number of nonconformities in external quality control studies</td>
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<td>21.7718</td>
<td>35.03996</td>
<td>0.00</td>
<td>239.00</td>
</tr>
<tr>
<td>Number of nonconformities in internal quality control studies</td>
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<td>429.6554</td>
<td>1,055.85696</td>
<td>0.00</td>
<td>8,531.00</td>
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<tr>
<td>Mediterranean Region</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Number of samples rejected</td>
<td>129</td>
<td>1,596.7907</td>
<td>3,932.83223</td>
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<td>26,330.00</td>
</tr>
<tr>
<td>Total number of samples sent to the laboratory</td>
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<td>405,693.5349</td>
<td>1,133,030.15418</td>
<td>0.00</td>
<td>11,630,835.00</td>
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<tr>
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<td>116</td>
<td>0.5339</td>
<td>1.05881</td>
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<td>10.57</td>
</tr>
<tr>
<td>Number of lost samples</td>
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<td>415.6667</td>
<td>3,704.40542</td>
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<td>41,126.00</td>
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<tr>
<td>Total number of samples taken</td>
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<td>410,886.5238</td>
<td>1,183,856.98259</td>
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<td>1,155,083.00</td>
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<td>Sample rate lost in biochemistry laboratory</td>
<td>113</td>
<td>0.0832</td>
<td>0.68889</td>
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<td>7.28</td>
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<tr>
<td>Number of results not delivered on time</td>
<td>129</td>
<td>15,377.7984</td>
<td>56,775.27712</td>
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<td>427,843.00</td>
</tr>
<tr>
<td>Total number of results given</td>
<td>129</td>
<td>728,909.6279</td>
<td>1,804,225.41410</td>
<td>0.00</td>
<td>1,197,557.00</td>
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<tr>
<td>Non-timely reported result rate</td>
<td>116</td>
<td>2.4876</td>
<td>4.60681</td>
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<td>26.16</td>
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<tr>
<td>Number of nonconformities in external quality control studies</td>
<td>124</td>
<td>19.8952</td>
<td>39.25771</td>
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<td>267.00</td>
</tr>
<tr>
<td>Number of nonconformities in internal quality control studies</td>
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<td>1,318.82351</td>
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<td>10,399.00</td>
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<td>Blacksea region</td>
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<tr>
<td>Number of samples rejected</td>
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<td>1,597.6414</td>
<td>7,296.12582</td>
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<tr>
<td>Total number of samples sent to the laboratory</td>
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<td>284,271.85166</td>
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<td>1,560,799.00</td>
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<tr>
<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>138</td>
<td>0.5475</td>
<td>1.03156</td>
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<td>11.48</td>
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<tr>
<td>Number of lost samples</td>
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<tr>
<td>Total number of samples taken</td>
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<td>1,798,240.00</td>
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<tr>
<td>Sample rate lost in biochemistry laboratory</td>
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<td>0.0534</td>
<td>0.25266</td>
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<td>1.76</td>
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<tr>
<td>Number of results not delivered on time</td>
<td>144</td>
<td>6,758.5139</td>
<td>15,830.42924</td>
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<td>108,451.00</td>
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<tr>
<td>Total number of results given</td>
<td>144</td>
<td>516,187.0764</td>
<td>962,451.27419</td>
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<td>7,105,637.00</td>
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<tr>
<td>Non-timely reported result rate</td>
<td>135</td>
<td>1.9434</td>
<td>3.08003</td>
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<td>18.47</td>
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<tr>
<td>Number of nonconformities in external quality control studies</td>
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<td>104.58017</td>
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<td>1,143.00</td>
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<tr>
<td>Number of nonconformities in internal quality control studies</td>
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<td>771.0764</td>
<td>4,966.20546</td>
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<td>57,653.00</td>
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<tr>
<td>Central Anatolia region</td>
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<tr>
<td>Number of samples rejected</td>
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<td>Total number of samples sent to the laboratory</td>
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<td>378,819.9186</td>
<td>790,606.54006</td>
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<td>7,694,690.00</td>
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<tr>
<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>157</td>
<td>0.5649</td>
<td>0.82262</td>
<td>0.00</td>
<td>6.99</td>
</tr>
<tr>
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<td>155.0000</td>
<td>1,653.72879</td>
<td>0.00</td>
<td>21,507.00</td>
</tr>
<tr>
<td>Total number of samples taken</td>
<td>170</td>
<td>329,324.6765</td>
<td>506,856.66180</td>
<td>0.00</td>
<td>3,049,747.00</td>
</tr>
<tr>
<td>Sample rate lost in biochemistry laboratory</td>
<td>154</td>
<td>0.0224</td>
<td>0.10840</td>
<td>0.00</td>
<td>0.83</td>
</tr>
<tr>
<td>Number of results not delivered on time</td>
<td>170</td>
<td>13,588.8059</td>
<td>69,814.42544</td>
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<td>873,157.00</td>
</tr>
<tr>
<td>Total number of results given</td>
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<td>758,747.4176</td>
<td>1,740,893.01152</td>
<td>0.00</td>
<td>12,573,236.00</td>
</tr>
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</table>
### Table 5: (continued)

<table>
<thead>
<tr>
<th>Geographic region</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Southeastern anatolia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-timely reported result rate</td>
<td>153</td>
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<td>0.00</td>
<td>21.40</td>
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<tr>
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<td>168</td>
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<td>20,666.00</td>
</tr>
<tr>
<td>Number of nonconformities in internal quality control studies</td>
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<td>7,050.66196</td>
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<td>81,747.00</td>
</tr>
<tr>
<td>Number of samples rejected</td>
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<td>2,187.2697</td>
<td>5,827.89320</td>
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<td>65,594.00</td>
</tr>
<tr>
<td>Total number of samples sent to the laboratory</td>
<td>330</td>
<td>376,048.7424</td>
<td>1,037,857.5607</td>
<td>0.00</td>
<td>15,323,925.00</td>
</tr>
<tr>
<td><strong>Marmara region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>310</td>
<td>0.6333</td>
<td>0.74911</td>
<td>0.00</td>
<td>4.28</td>
</tr>
<tr>
<td>Number of lost samples</td>
<td>331</td>
<td>206.5378</td>
<td>3,584.37006</td>
<td>0.00</td>
<td>65,202.00</td>
</tr>
<tr>
<td>Total number of samples taken</td>
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<td>415,306.2387</td>
<td>1,743,033.59773</td>
<td>0.00</td>
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</tr>
<tr>
<td><strong>Eastern anatolia region</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of samples rejected</td>
<td>92</td>
<td>1917.3043</td>
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<td>0.00</td>
<td>28,981.00</td>
</tr>
<tr>
<td>Total number of samples sent to the laboratory</td>
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<td>610,002.6630</td>
<td>2,410,457.98317</td>
<td>0.00</td>
<td>21,323,820.00</td>
</tr>
<tr>
<td><strong>Southeastern anatolia region</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of samples rejected</td>
<td>96</td>
<td>2,193.4062</td>
<td>4,334.53969</td>
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<td>30,355.00</td>
</tr>
<tr>
<td>Total number of samples sent to the laboratory</td>
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<td>358,290.2708</td>
<td>739,258.44517</td>
<td>0.00</td>
<td>5,869,369.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of samples rejected</td>
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<td>1973.8126</td>
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<td>0.00</td>
<td>86,368.00</td>
</tr>
<tr>
<td>Total number of samples sent to the laboratory</td>
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<td>0.00</td>
<td>21,323,820.00</td>
</tr>
<tr>
<td>Sample rate rejected in biochemistry laboratory tests</td>
<td>1,029</td>
<td>0.6229</td>
<td>1.04811</td>
<td>0.00</td>
<td>20.69</td>
</tr>
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<td>Number of lost samples</td>
<td>1,111</td>
<td>241.3240</td>
<td>3,539.00471</td>
<td>0.00</td>
<td>86,108.00</td>
</tr>
</tbody>
</table>
In the literature, there are studies showing that staff working in all clinics that take samples and laboratory technicians are regularly trained on pre-analytical errors before and during the task, thereby contributing to the prevention of labor and economic losses due to pre-analytical errors in laboratory services [22–24].

Number of nonconformities in biochemistry laboratory internal/external quality control studies are calculated as “In the relevant period; number of nonconformities on the basis of test in internal/external quality control studies” So it is not correct to make comparisons between hospitals because it does not give a ratio. The most important thing is to carry out and continue the necessary studies and maintenance on the devices for the tests that are inappropriate in internal and external quality control studies until the tests become suitable.

“Non-timely reported result rate in biochemistry laboratory” is one of the important indicators showing the quality of the postanalytical process. It has been determined that this indicator had the highest rate. The reasons for this situation may include wrong patient protocol, late reporting of panic results, late approval of the report, and transition errors between the laboratory information system and the hospital information system.

In our study, the most common error rate except “Non-timely reported result rate in biochemistry laboratory” was seen in university hospitals. When we searched for literature, we could not find a study comparing the hospital types. In the university hospitals various tests are carried out, so different types of test tubes and devices are used. So it can be difficult to master.

Although we had expected the biochemistry laboratory error rates to be higher in the Marmara region as the number of hospitals were the highest when we compared the indicators according to regions the highest “Non-timely reported result rate in biochemistry laboratory” was in Aegean region and the lowest rate was in Eastern Anatolia region. However the highest “Lost sample rate...
in biochemistry laboratory” was seen also in Eastern Anatolia region.

Our study represents an important contribution to the literature with comparing the hospitals types and presenting the general data in Turkey.

Conclusion

The non-timely reported result rate is the most common adversity. In addition, the error rates in the university hospitals are higher than public and private hospitals. The root cause needs to be analyzed well and necessary measures must be taken by those responsible.

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Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest statement: The authors declare that there is no conflict of interest.

Financial disclosure statement: There is no financial interest.

References