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Enhancing Laboratory Efficiency with Total Laboratory Automation

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Abstract

Background: To improve workflow efficiency, we periodically analyzed the key performance indicators (KPIs) for our total laboratory automation (TLA) system, including the preanalytic processing system, centrifuge, biochemistry analyzer, immunoassay analyzer, and storage refrigerator. Providing the useful information for the potential TLA decision-makers.

Methods: Comparisons of KPIs before and after implementation of total lab automation were collected from July 2016 to August 2019 from the biochemistry and immunoassay group in the clinical laboratory of Shanghai Tong Ren Hospital. The pros and cons of the laboratory automation system were analyzed, and potential improvements were proposed.

Results: There was a 88.91% and 76.97% increase in immunology and chemistry tests in July 2019 compared to July 2016 (before and after implementation of TLA). Biochemical and immunoassay turnaround time (TAT) was reduced by an average of 2 and 4 hours respectively. With normal daily use of TLA and adoption of optimized processes, turnaround time (TAT) was reduced in the first few months of TLA operation. There was a significant difference in the total amount of tubes handled by the Input/Output Module (IOM) before and after process optimization. Better operational synchronization of the two centrifuges was the most important factor in this improved performance. Prior to optimization, the total number of tubes unloaded and loaded on the IOM during each time period did not exceed 700. The highest number of tubes was 653 at 10 a.m. After optimization, centrifuge 1 and centrifuge 2 centrifuged 919 and 908 specimens respectively. The two centrifuges peaked at 9 a.m., centrifuging 248 and 234 specimens respectively. Biochemical TAT and immunoassay TAT were shortened by 22 and 37.6 minutes on average respectively after optimization. There are still some defects in TLA, such as the slower detection speed of overall Immunoassay compared with Biochemical, so the maximum efficiency of TLA still has bottlenecks. Moreover, we even need earlier pre-analytical step for total efficiency enhancement integratedly.

Conclusion: Undoubtedly TLA significantly increased the efficiency of the clinical laboratory, however, some subtle points should be considered beforehand.

Keywords: Total laboratory automation; Key performance indicators; Workflow; Lab management; Immunoassay; Biochemistry; Turnaround time

Abbreviations: TLA: Total Laboratory Automation; IOM: Input/Output Module; MPA: Modular Pre-Analytics; LIS: Laboratory Information System; IT: Information Technology; Chem: Chemistry; Immu: Immunology; TAT: Turnaround Time.

Introduction

Masahide Sasaki first introduced the automated clinical laboratory in the early 1980s. This began a worldwide revolution in clinical laboratory automation. In China, we witnessed a boom in laboratory automation at the beginning of the 21st century, applied to areas including microscopic examination, physical and chemical analysis, and single-machine automation. Continued integration and informationization have made possible total laboratory automation, or TLA. TLA can comprehensively improve the level of laboratory quality and ultimately support breakthrough improvements in lean management of laboratories [1]. TLA aims to integrate and automatically control operation of all analyzers and accessory equipment connected to a sample-transport track, thereby fully automating sample transportation, classification, pretreatment, detection, result reporting, and post-storage. Currently available lab automation systems make TLA more accessible to mid- and high-volume clinical laboratories [2].

Shanghai Tong Ren Hospital is a regional central hospital in China with more than 1200 beds that also treats 2.5 million outpatients annually. In addition to providing services for the hospital, the hospital's clinical laboratory serves as a reference laboratory for Changning District. The laboratory performs more than 7 million inpatient and outpatient tests (immunoassay and biochemistry) annually. To improve its operational efficiency and accommodate rapidly increasing sample volume, the lab implemented a next-generation automation system. This new automated system includes an Input/Output Module (IOM), preprocessing and auto-sorting modules, two online centrifuges, three biochemistry analyzers, six immunoassay analyzers, and a refrigerated specimen storage cabinet,

all of which are connected to a sample-transport track. Since installation of this comprehensive TLA in March 2017, the lab has observed profound improvements in turnaround time (TAT), quality control, and the number of technicians required for operation. Added value has also emerged in terms of informatics, autoverification, and more-effective planning, to name a few examples.

In order to evaluate the practical role of TLA and exploit its full potential, we compared lab performance data collected before and after implementation of the TLA system using daily records obtained from the system. We evaluated TLA's advantages and disadvantages and adjusted our workflow to accommodate changes in our medical service. The results we obtained may provide valuable information, benchmarks, and useful advice for peer laboratories.

Materials and Methods

Total laboratory automation system

We used the Aptio ® Automation system from Siemens Healthineers. Our automated configuration is as follows: 1 track module, 1 Input/ Output module (IOM), 1 Bulk Input Module (BIM), 2 Centrifuge Modules (CM), 1 Decapper Module (DCM), 1 Desealer Module (DSM), 1 Refrigerated Storage Module (RSM), 1 Sealer Module (SM), and 9 connected clinical analyzers (3 ADVIA ® 2400 Clinical Chemistry Systems and 6 ADVIA Centaur ® XP Immunoassay Systems). Table 1 includes a brief description of the TLA and each component connected to the automation track.

Module	Description	Quantity
Input/ Output	800-sample loading/unloading capacity; 800 tubes/hour; identification of tube type, bar-code reading, interaction with operator, automation through a graphical interface, and tracking operations in progress in the tubes	1
Centrifuge	300 tubes/hour; 1000–4500 RPM; automates centrifugation of samples	2
Decapper	800 tubes/hour; automates removal of screw caps and pressure caps	1
Sealer	800 tubes/hour; automatically heat-seals tubes with aluminum foil after analysis	1
Desealer	200 tubes/hour; automatically removes seal from tubes that need to be rerun	1
Refrigerated Storage	800 tubes/hour; refrigerated storage capacity 15,000 tubes; automatically stores tubes, which can be recalled on request and discarded after a configurable time	1
Bulk Input	800 tubes per hour; automated sample input processing	1
Track	3600 tubes per hour; U-turn track supports rapid divert module; total tube-travel distance is 97 m; travel time is 9.5 minutes. Entire TLA system occupies 3000 sq. ft.	1
ADVIA 2400 system	General chemistry analyzer	3
ADVIA Centaur XP system	Immunoassay analyzer	6

Table 1: TLA components.

Middleware consists of the CentraLink ® Data Management System and Datalink. Our laboratory information system (LIS) is by Lanheng Information Systems Inc.

Volume of tests before and after TLA implementation

We started using the Aptio Automation system in March 2017. Our previous chemistry and immunoassay analyzers were from Roche Diagnostics Corporation. To evaluate whether the TLA system improved operational efficiency, we identified various metrics to understand and monitor our workflow. Key performance indicators were collected from 2016 to 2019 from the chemistry and immunoassay group of the clinical laboratory of Shanghai Tong Ren Hospital. The data were selected each year in July and compared before and after implementation of TLA. Also, we used process mapping to document productivity before and after implementation.

Improvements in the first few months of TLA

Comparison of TAT data before and after TLA: TAT data were analyzed for the 2 months before (January 2017 to February 2017) and 2 months after (March 2017 to April 2017) implementation of TLA. Prior to the implementation of TLA, calculation of TAT included the time from specimen login in the laboratory information system to report review. To evaluate the efficiency of the Aptio Automation TLA system, data were collected to establish the in-lab to reporting turnaround (IR-TAT) time—the time from which samples were loaded onto the Input/Output Module (IOM) until results were verified by the LIS. The date of TAT was obtained from the CentraLink system. All of the date take their mean.

Comparison of TAT data after priority sampling: Because of the shortage of infectious-disease assay data in the TLA system, improvement in TAT was analyzed after priority sampling.

Improvement of TLA operation in 2019

With the sharp increase in specimen volume after TLA implementation, TLA workload also increased. The overall efficiency of the TLA system was reduced, and TAT increased. The efficiency of the TLA system continued to decline.

To find out why, in April 2019 we identified various metrics to understand and monitor our workflow. We observed that there was a significant difference in the volume of samples centrifuged daily between the two centrifuges. From analysis of dashboard data, we learned that the number of specimens loaded onto the IOM was too

large, leading to decreased efficiency of TLA as a whole. To solve this problem, we reset system parameters and improved our operating process to improve the efficiency of TLA beginning in May 2019.

Data before and after process improvement were randomly selected for analysis. Data from April 23, 2019, were chosen to represent operations before process improvement, and data from August 13, 2019, were chosen to represent operations post-improvement.

Results

Volume of tests processed before and after TLA implementation

The number of tests processed for immunology and chemistry analytes in the pre and post-TLA periods is reported in Table 2. We observed a 37.45% increase in immunology and 2.75% increase in chemistry test volume in July 2017 compared to July 2016. There was a 88.91% and 76.97% increase in immunology and chemistry test volume in July 2019 compared to July 2016 (before and after implementation of TLA). There was a 37.44% and 72.23% increase respectively in July 2019 compared to July 2017 (all post-implementation of TLA; Figure 1).

	Jul-16	Jul-17	Jul-18	Jul-19	% Increase 2016 to 2017	% Increase 2017 to 2018	% Increase 2018 to 2019	% Increase 2016 to 2019	% Increase 2017 to 2019
Immunology	87,257	1,19,936	1,44,979	1,64,835	37.45%	20.88%	13.70%	88.91%	37.44%
Chemistry	2,30,781	2,37,132	3,09,257	4,08,421	2.75%	30.42%	32.07%	76.97%	72.23%
Technicians/day	6	6	6	6	0	0	0	0	0

Table 2: Volume of immunology and chemistry analytes processed from July 2016 to July 2019.

The TLA system is expected to produce 7 million test results per year. In 2016, before TLA, six technicians were employed in the lab every day (Table 2). At the rate of workload growth we experienced, we would have needed twice the number of staff by 2019 to accommodate the extra workload. However, due to implementation of TLA and on-going process optimization measures, we were able to process the much higher sample volume in 2019 with the same number of staff.

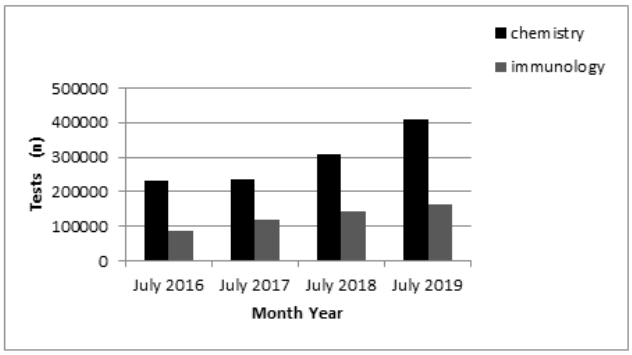

Figure 1: Volume of tests before and after implementation of TLA.

Improvements in the first few months of TLA

With routine use of TLA for daily operations and gradual optimization of operating processes, TAT was reduced.

IR-TAT comparison between the pre- and post-automation periods: We analyzed TAT data for a period of 2 months before (January 2017 to February 2017) and 2 months after (March 2017 to April 2017) implementation of TLA. Prior to the implementation of TLA, the mean TATs for chemistry and immunology were 3.5 hours and 5.5 hours respectively. Post-TLA, the mean TATs for chemistry and immunology were 50 minutes and 71 minutes. For chemistry, TAT before and after TLA was shortened by 2 hours on average. Immunology TAT was shortened by 4 hours on average.

TAT analysis for TLA after running for 2 months: After running TLA for 2 months, the average chemistry TAT in March 2017 was 50 minutes and in April 2017 was 45 minutes. Average immunology TAT in March 2017 was 80 minutes and in April 2017 was 71 minutes. After 3 weeks of TLA operation, we found that some immunology tests, such as CA 19-9 and HBsAg, had a longer response time, leading to an overall increase in TAT for all specimens.

To solve this problem, we used the Aptio Automation system's powerful CentraLink and Datalink middleware to optimize workflow and set up priority sampling and analysis for these types of assays. TAT was greatly reduced as a result. With continuous process improvement, TAT trended lower, especially immunology TAT. This was more obvious in April than in March, since TLA had by then been running for 2 months.

Change in TAT after priority processing of infectious-disease assays: After 3 weeks of TLA operation, we found that some immunoassays, such as CA 19-9 and HBsAg, had a longer reaction time (Table 3). Also, results for some assays such as hepatitis B and hepatitis C fell in the gray area, and the samples needed to be retested. According to TLA operating statistics, the rerun rate was 17%, resulting in increased TAT for some specimens. In view of this situation, priority was given to processing these types of tests to speed up specimen testing. In particular, specimen reruns could be completed within 140 minutes. According to the comparison and analysis of the operational data for hepatitis B testing, TAT was significantly shortened, with an average

reduction of 40 minutes between the 3099 samples tested before optimization and the 2933 samples tested after first sampling, as shown in Figure 2.

Assay	Reaction Time (min)	Assay	Reaction Time (min)
T3	17.5	PRGE	17.5
T4	17.5	TSTO	17.5
FT3	17.5	IRI	17.5
FT4	17.5	CPS	17.5
TSH	17.5	aTG	17.5
AFP	17.5	aTPO	17.5
CEA	17.5	aHBs	17.5
CA 15-3	57.25	HBs	28.5
CA 19-9	57.25	HBeAg	57.25
THCG	17.5	aHBe	17.5
LH	17.5	HBcT	52.25
FSH	17.5	aHBcIgM	57.25
PRL	17.5	SYPH	28.5
eE2	17.5	HCV	57.25

Table 3: Reaction times for immunology assays.

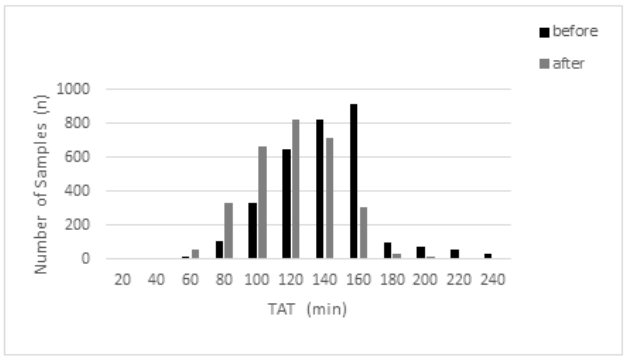

Figure 2: TAT distribution map of infectious-disease assays before and after process optimization.

Improvement of TLA operation in 2019

Improvement in IOM operating efficiency: The IOM provides a single point for input, output, and bar-code identification of sample tubes. The ideal maximum capacity of the IOM is 800 tubes. If the total number of tubes held by the IOM exceeds 800, the input speed of specimens is affected, greatly reducing the operating efficiency of the TLA system. Table 4 shows the total number of tubes unloaded and loaded on the IOM before and after optimization.

Parameters	Pre-improvement	Post-improvement
Peak Total Tubes	812	653
Peak Unload Tubes	360	363
Peak Load Tubes	452	290
Module Peak Hour	9	10
Percent Loaded (%)	55.67%	44%
Peak Hour Utilization (%)	101.50%	81.63%

Table 4: IOM improvement metrics.

Before optimization, the total number of tubes unloaded and loaded on the IOM during five time periods exceeded 700. The highest number of tubes was 812 at 9 a.m., which exceeded the total maximum capacity of the IOM. After optimization, the total number of tubes unloaded and loaded on the IOM during each time period did not exceed 700. The highest number of tubes was 653 at 10 a.m. There is a significant difference in the total amount of tubes loaded and unloaded on the IOM in each period prior to and after optimization (Figure 3).

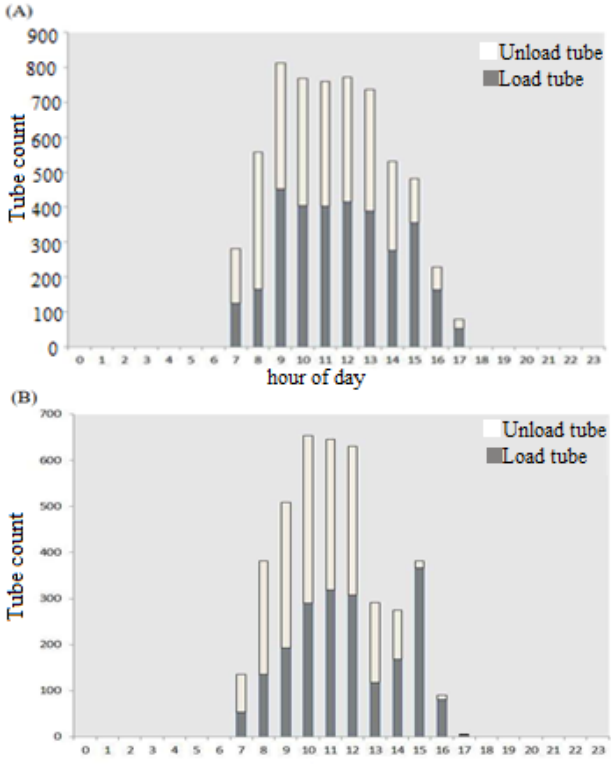

Figure 3: Distribution map of tubes loaded and unloaded on the IOM before and after optimization. (A) for the IOM before optimization and (B) for the IOM after optimization.

Improvement in centrifuge operating efficiency: The Centrifuge Module automates centrifugation of samples to separate their various components. The Centrifuge Module includes loading and unloading areas. The total number of tubes processed on the two centrifuges before and after process optimization is shown in Table 5.

	Pre-improvement		Post-improvement	
Parameters	**Centrifuge-1**	**Centrifuge-2**	**Centrifuge-1**	**Centrifuge-2**
TotalTubes	649	1281	919	908
PeakHourTubes	190	281	248	234
PeakHour	12	12	9	9
PeakHour	29.28%	21.94%	26.99%	25.77%
PeakHour Utilization (%)	63.33%	93.67%	82.67%	78.00%
MeanTAT	45.2 Min	30.3 Min	31.5 Min	33.2 Min
MedianTAT	30.7 Min	25.6 Min	27.2 Min	28.3 Min
ModeTAT	30.7 Min	19.5 Min	25.9 Min	23.50%
SDTAT	30.81 Min	12.42 Min	11.88 Min	13.23 Min
MinTAT	14.3 Min	12.5 Min	13.9 Min	14.3 Min
MaxTAT	144.1 Min	68.6 Min	61.6 Min	66.6 Min
99thTAT	124.95 Min	59.53 Min	53.07 Min	58.29 Min

Table 5: Centrifuge process improvement metrics.

Before optimization, centrifuge 1 processed a total of 649 specimens. Peak volume was at 12 p.m., with 190 specimens centrifuged. The peak utilization rate was only 63.33%, and mean TAT was 45.2 minutes. In contrast, centrifuge 2 processed 1281 specimens at 12 p.m., with a peak utilization rate of 93.67% and mean TAT of 30.3 minutes. Before process optimization, the operating efficiency of the two centrifuges was significantly different , shown above in Figure 4.

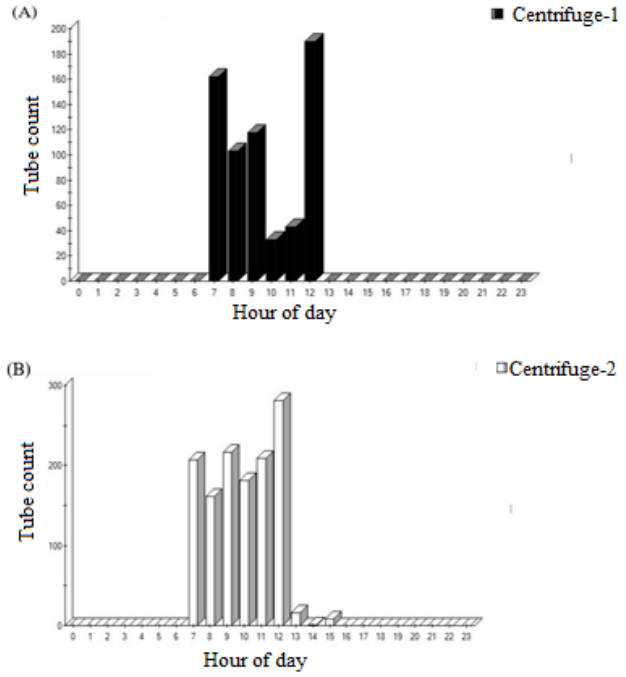

Figure 4: Distribution map of total tube volume on two centrifuges before process optimization. (A) for the centrifuge-1 before optimization and (B) for the centrifuge-2 before optimization.

After optimization, centrifuge 1 processed a total of 919 specimens. Peak volume was at 9 a.m., with 248 specimens centrifuged. Peak utilization was 82.67%, and mean TAT was 31.5 minutes. Centrifuge 2 processed a total of 908 specimens. Peak volume was at 9 a.m., with 234 specimens centrifuged. Peak utilization rate was 78.00%, and mean TAT was 33.2 minutes. After optimization, there was no obvious difference in the operating efficiency of the two centrifuges (Table 5 and Figure 5).

Improvement in TAT: The TLA system has been in operation for nearly three years since 2017. During this time, sample volume increased sharply, as did the load on the TLA system. Over time, we noticed the TLA system's efficiency decreasing and the TAT gradually increasing. In response, we made changes to operating processes and workflow to improve efficiency and reduce TAT to acceptable levels. These changes are described in section 4, Discussion.

Mean, minimum, maximum, standard deviation, coefficient of variation, median, 25th percentile, 75th percentile, and 95th percentile TAT values before and after process optimization are shown for immunology analytes and chemistry analytes in Table 6.

Before optimization, the mean TAT for immunology analytes was shortest at 16:00 (4 p.m.), at 51 minutes. The mean TAT was longest at 14:00 (2:00 p.m.), at 121 minutes. The average TAT at each time of day was over 50 minutes; most of the specimens were close to 100 minutes, with the longest TAT reaching 249 minutes.

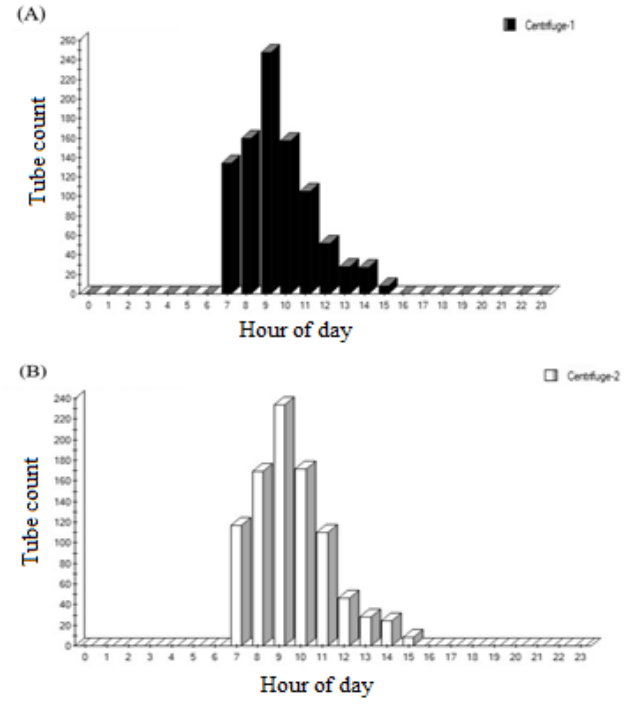

Figure 5: Distribution map of total tube volume on two centrifuges after process optimization. (A) for the centrifuge-1 after optimization and (B) for the centrifuge-2 after optimization.

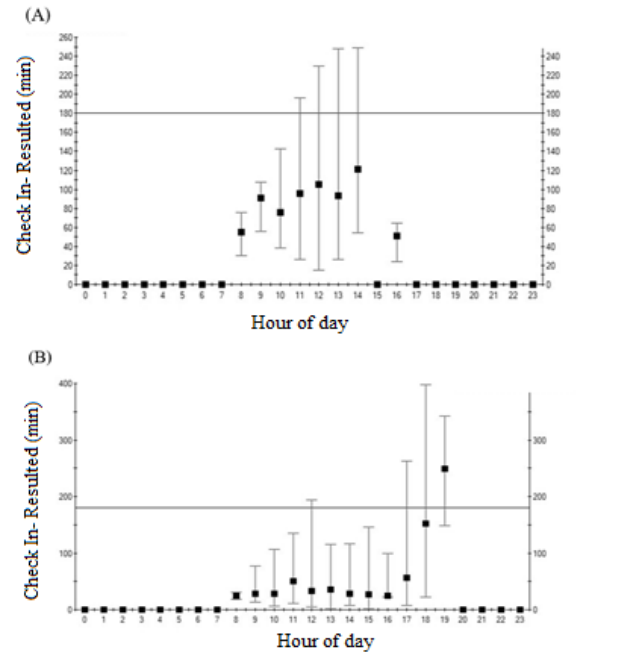

Figure 6: TAT distribution map for immunology analytes before and after process improvement. (A) for before process improvement and (B) for after process improvement.

After optimization, the shortest mean TAT for immunology samples was 21 minutes at 16:00 (4:00 p.m.), and the longest mean TAT was 78 minutes at 13:00 (1:00 p.m.). The average TAT at each time of day was no more than 80 minutes, and most specimens were completed within 100 minutes, shown above in Figure 6.

Before optimization, the mean TAT for chemistry analytes was the shortest at 15:00 (3 p.m.), at 20 minutes. The mean TAT was the longest at 11:00 (11 a.m.), at 107 minutes. The average TAT at each time of day was over 50 minutes; most of the specimens were close to 90 minutes, with the longest TAT reaching 250 minutes.

After optimization, the shortest mean TAT for chemistry samples was 10 minutes at 16:00 (4 p.m.), and the longest mean TAT was 60 minutes at 9:00 (9 a.m.). The average TAT at each time of day was no more than 60 minutes, and most specimens were completed within 60 minutes (Figure 7).

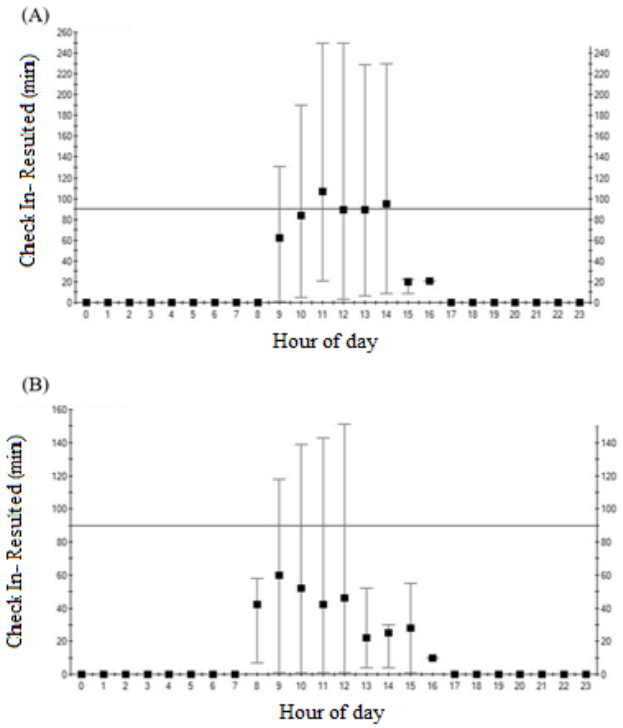

Figure 7: TAT distribution map for chemistry analytes before and after process improvement. (A) for before process improvement and (B) for after process improvement.

For immunology analytes prior to optimization, TAT mean, median, mode, standard deviation, and 95th percentile were 92.1, 80, 78, 47.73, and 205 minutes respectively. After optimization, TAT mean, median, mode, standard deviation, and 95th percentile were 70.1, 63, 21, 35.1, and 116 minutes respectively (Table 6).

For chemistry analytes prior to optimization, TAT mean, median, mode, standard deviation, and 95th percentile were 86.5, 57, 42, 61.93, and 184 minutes respectively. After optimization, TAT mean, median, mode, standard deviation, and 95th percentile were 48.9, 48, 16, 28.13, and 94 minutes respectively. TAT for immunology and chemistry analytes was obviously reduced after optimization (Table 6).

Parameter	Pre-improvement		Post-improvement	
	Immunology	Chemistry	Immunology	Chemistry
Number	3755	15773	3890	14868
Mean TAT (Min)	92.1	86.5	54.1	48.9
Median TAT (Min)	80	57	23	48
Mode TAT (Min)	78	42	23	16
SD TAT (Min)	47.73	61.93	70.74	28.13
95th TAT (Min)	205	184	88	94

Table 6: TAT (in minutes) before and after TLA process improvement.

Discussion

The integration and informationization of laboratory medicine have promoted development of TLA, especially in light of the potential demand for TLA from China's demographic conditions and medical system. The in-depth consideration and exploration of TLA quality and efficiency are bound to have a profound impact on the lean management of clinical laboratories in China.

Automation of the clinical laboratory freed our staff from manual blood sorting, numbering, centrifugation, and other tedious tasks. The specimen pre-treatment stage, with its high incidence of manual inspection errors, was completely automated, thereby automating and standardizing the entire inspection process and greatly reducing errors caused by manual inspection.

Our data show a 88.91% and 76.97% increase in immunology and chemistry test volume in July 2019 compared to July 2016, before and after implementation of the TLA. In addition, there was a 37.44% and 72.23% increase respectively in July 2019 compared to July 2017, during which time TLA was fully implemented in daily use. The data show a sharp increase in workload, almost double that in 2016, but the number of the daily staff remained the same, and we even operated with fewer staff occasionally. These data reflect significant workflow and financial benefits with the implementation of a TLA system.

For successful implementation, a stepwise approach minimizes the potential for issues that may significantly affect patient care. Substantial preplanning is necessary when designing the workflow, information technology (IT), and configuration of instrumentation to optimize efficiency. Through in-depth longitudinal analysis, we improved the workflow, track transport efficiency, software application, and other aspects of the TLA system to achieve progressively greater operating efficiency.

Specimen turnaround time (TAT) is the time between the clinician issuing test instructions and the return of test results, which reflects the timeliness of laboratory reports. TAT is one of the most important indexes to measure the service level of the laboratory and evaluate the laboratory's testing ability [3].

The time period that can be controlled by the laboratory spans the time when the test specimen is sent to the laboratory to the time when the test report is sent out. This is called the specimen turnover time. Traditional pre-treatment work consists of many manual tasks, is very complicated, and can make it difficult for the lab to achieve TAT sufficient to meet clinical needs. Before we implemented TLA, chemistry test reports were usually not available until 3:00 to 4:00 p.m. on the day of testing, and reports for many immunology tests were not available until the second day. This delay affected clinical diagnosis, treatment, and patient satisfaction and was also a major difficulty in the management of the laboratory [4].

Manual processing results in inconsistent, excessively long TAT, while TLA not only significantly reduces TAT, but also makes it more consistent and predictable. The difference between the two is that the former has different nodes and time points. When the specimen arrives in synch with the nodes and time points, it can be processed immediately, and TAT is short. Otherwise, it can only wait for the next batch of processing, and TAT will be extended. In contrast, TLA runs at a constant speed, and samples can be analyzed without delay when they arrive at the analyzer, so TAT is not only reduced but also controllable. TLA has demonstrated an increase in laboratory efficiency and improved TAT in clinical laboratories that have adopted it [5-8].

In addition, with the support of the LIS and middleware, TLA can carry out automatic real-time monitoring of the samples on the system and intelligently perform dilutions, additional tests, serum index testing (to detect the degree of serum haemolysis, jaundice, and lipid blood), automatic extraction, and other operations according to predefined rules. These functions greatly reduce the intensity of work for laboratory staff and substantially reduce mistakes.

From analyzing the data collected 2 months before and after we implemented TLA, we observed that TAT after implementation was significantly shorter than before, which is consistent with results reported in the literature. The track-based transport system supports full automation of sample transportation, bar-code scanning, classification, centrifugation, sample aspiration, and final preservation and storage, reducing time spent on manual processes and eliminating mistakes. The advantages of automatic analysis are well-known. The automation system software can control the analyzers on which individual specimens are tested.

Using accurate statistics for the time specimens spent at each analyzer, we were able to analyze the distribution of analysis time across the TLA and clarify the "short-board" tests (assays with long reaction times). For example, the reaction time was long for hepatitis B and tumor assays, so TAT for immunoassays was long when TLA was first implemented. We therefore designated these assays for priority processing to mitigate their negative impact on overall TAT; optimize TAT for online samples; meet the needs of clinical diagnosis, treatment, and fast medical services; and achieve a win-win situation regarding social and economic benefits for the hospital.

With the sharp increase in specimen volume we experienced after implementation of TLA, the TLA workload also increased. The existing workflow and parameter settings could no longer meet processing needs, the efficiency of the TLA system began to decline, and TAT began to increase.

This decline continued until April 2019, when we learned from the analysis of dashboard data that the sample load on the IOM was too large, exceeding the ideal maximum capacity of 800 tubes and resulting in reduced overall efficiency of the TLA system. To solve this problem, we then began an initiative to optimize our operating processes.

In the workflow prior to optimization, specimen was loaded on the TLA, centrifuged, decapped, and sampled. Then the specimen was parked on the IOM so that it could easily be grabbed by the carrier if a rerun was required. If, after sample review, no rerun was required, the specimen parked on the IOM was grabbed by the carrier, transported to the resealer, and put into the refrigerator. The problem with this scheme was that most of the specimens parked on the IOM did not require reruns and therefore were parked there unnecessarily, resulting in overloading of the IOM and carrier and reduced efficiency of the TLA system.

We optimized this process to cancel the parking function on the IOM. After sample aspiration, the tube is sealed and stored in the refrigerator, and the carrier is quickly released for testing of the next sample. The turnover frequency and volume of samples on the track and in the IOM are reduced, which improves operating efficiency. If the specimen needs to be retested, the operator can request a rerun using system software. The TLA system then removes the specimen from the refrigerator, removes the cap and seal, and retests the sample. After aspiration, the specimen is resealed and placed back in the refrigerator. The result of this optimization is that the load on the IOM is reduced, and operating efficiency of the TLA system is improved.

Through observation, we also found that the workload of the two centrifuges was significantly different. One centrifuge was working at full load, while the other was half-empty. Specimens could not be centrifuged quickly enough keep up with the running speed of the TLA system, which led to the decreased TLA efficiency and increased TAT. To solve this problem, we reset the centrifuge parameters. After repeated debugging, the workload of the two centrifuges was finally balanced, which improved the centrifugation speed, sped up specimen analysis, and reduced TAT.

An advantage of TLA is its ability to manage large volumes of specimens. TLA systems provide a standard, consistent solution for rapid throughput. However, there are still some defects in TLA, such as the slower detection speed of overall Immunoassay compared with Biochemical, so the maximum efficiency of TLA still has bottlenecks. In addition, a number of parallel biochemical analyzer and Immunoassay analyzer on TLA need to be compared with the same items, so the cost of quality control is increased.

Conclusion

Successful implementation of TLA requires proper planning and stepwise execution. On-going optimization with monitoring of key metrics, as well as continuous process improvement, is necessary to maximize and maintain efficiency gains. By taking advantage of the powerful functions of the CentraLink and Datalink middleware of the Aptio Automation system, we continue to give priority to the analysis of "short-board" assays, coordinate and balance the system functions of the TLA, optimize our workflow, and improve overall efficiency.

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