RESEARCH ARTICLE

National survey on turnaround time of clinical biochemistry tests in 738 laboratories in China

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Background: This survey was initiated to estimate the current status of turnaround time (TAT) monitoring of clinical biochemistry in China, provide baseline data for establishment of quality specifications and analyze the impact factors of TAT.

Methods: 738 laboratories were included. Questionnaires involved general information and data of related indicators of TAT during 1 week were provided to participating laboratories. Nine quality indicators were covered, which were medians, 90th and outlier rates of pre-examination, examination, and post-examination TAT. The 25th percentile, median, and 75th percentile of TATs were calculated as optimum, desirable, and minimum quality specifications. Percentages and sigma values were used to describe the outlier rates. Mann-Whitney and Kruskal-Wallis tests were used to identify the potential impacts of TAT.

Results: Response rate of this survey was 46.44%. More than 50% of the laboratories indicated they had set up target TATs in three time intervals and monitored TATs generally. The post-examination TAT of most laboratories was 0min, while the pre-examination and examination TAT varied. Sigma values of outlier rates for 45%~60% of laboratories were above 4, while 15%~20% of labs whose sigma values were below 3. Group comparisons suggested nurse or mechanical pipeline transportation, link laboratory information system with hospital information system, and using computer reporting instead of printing report were related to shorter TATs.

Conclusions: Despite of the remarkable progresses of TATs in China, there was also room to improve. Laboratories should strengthen the construction of information systems, identify reasons for TAT delay to improve the service quality continuously.

KEYWORDS

clinical laboratory, quality control, quality indicators, turnaround time

1 | INTRODUCTION

Laboratories tend to focus more on the technical and quality for the accuracy and reliability of test results. However, clinicians and patients value the timeliness of results reporting, and they might agree to sacrifice some analytical quality in order to obtain more rapid results.¹ For

that reason, many clinicians prefer to employ point of care (POC) testing. Turnaround time (TAT) is one of the most vital quality indicators (QIs) and always considered as a key indicator of laboratory services.² Delayed TAT will immediately lead to complaints from patients and clinicians.

TAT is defined as "elapsed time between two specified points through pre-examination, examination, and post-examination processes" according to ISO 15189:2012,³ including time of clinician

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requisition, sample collection, sample transportation, sample analysis, etc. It also stated that "laboratories should determine the TAT for each analytes, and audit whether laboratories can meet the goal TAT regularly." Clinical Laboratory Improvement Amendments (CLIA'88), College of American Pathologists (CAP) and International Federation of Clinical Chemistry (IFCC) have set requirements for TAT monitoring in clinical laboratories, as well.^{4,5}

Chinese National Center for Clinical Laboratories (NCCL) has conducted a national investigation on intra-laboratory TAT in 2011, which demonstrated the unsatisfied performance of intra-TAT.⁶ In order to further study the baseline of TAT across the total testing spectrum, and help clinical laboratories to set their appropriate goal TAT, an overall investigation on TAT nationwide were conducted. This survey involved nine quality indicators, which were medians, 90th and outlier rates of pre-examination, examination, and post-examination TAT. Pre-examination TAT was defined as the time taken from sample collection to reception, examination TAT was the time taken from reception to results reporting, and post-examination TAT was the time from results reporting to results reception by clinicians.

2 | MATERIALS AND METHODS

2.1 | Study design

In total 1589 clinical laboratories in China, which had participated in clinical biochemistry of external quality assessment (EQA) programs organized by the NCCL were included in this survey in July 2015. Private laboratories, Centers for Clinical Laboratories, and independent commercial laboratories were excluded for their various TATs. Questionnaires that covered two parts were sent to participating laboratories. The first part was about the general conditions of participating laboratories: 1) general information on clinical laboratories and hospitals; 2) investigation on TAT monitoring; 3) elements that may influence TAT. Kolmogorov-Smirnov (K-S) test indicated the distributions of TAT data were non-Gaussian with a positive skew, indicated that median and tail size are the preferred measures.⁷ Therefore, the second part was aimed to collect the data of TATs during 1 week according 9 QIs: median of pre-examination TAT, median of examination TAT, median of post-examination, 90th of pre-examination TAT, 90th of examination TAT, 90th of post-examination TAT, outlier rates of pre-examination TAT, outlier rates of examination TAT, and outlier rates of post-examination TAT. Eight tests were involved in the questionnaire of routine biochemistry analytes, including potassium, glucose, total protein, alanine transaminase (ALT), magnesium, triglyceride, creatine kinase-MB (CK-MB), and troponin (cTn) respectively. Five tests were provided in the questionnaire of stat biochemistry analytes, including potassium, glucose, CK-MB, cTn, and amylase. Related indicators of TATs were separately analyzed in accordance with routine biochemistry analytes and stat ones. Stat tests were tests ordered when the results urgently needed, particularly for patients with severe diseases, patients from emergency department, and inpatients whose condition change suddenly.

2.2 | Data collection

All laboratories were informed of the EQA program of TAT investigation by both paper and message notification and asked to submit the questionnaire within 1 month after receiving it. Electronic notice and guidelines for data filling in can be downloaded from an online EQA platform developed by NCCL (www.clinet.com.cn).⁸ The data of nine QIs of TATs in laboratories can be collected via either laboratory information system (LIS) or manually. Three methods were given for laboratories in submitting their results likewise, online EQA platform, E-mail and regular mails respectively. Besides, this EQA program of TAT investigation is free of charge and without punishment.

2.3 | Statistics analysis

All the collected data were calculated and analyzed through the special statistical software designed by NCCL and developed by the Clinet information technology (Beijing, China) and SPSS 19.0 (SPSS Inc., Chicago, IL, USA). Percentage (%) and sigma (σ) were used to evaluate indicators of outlier rates in three time intervals. Percentage of outlier rate was considered as the number of specimens exceeding the goal TAT set by a laboratory dividing by the total number of

TABLE 1 General information about participating laboratories in national survey on turnaround time

Group	N	%
Type of hospital		
Tertiary hospital	590	80.0
Non-tertiary hospital	148	20.0
ISO 15189 or CAP accreditation		
Yes	89	12.1
No	649	87.9
Method of sample transportation		
Laboratory staff transportation	58	7.9
Professional staff transportation	466	63.1
Nurse transportation	135	18.3
Mechanical pipeline transportation	52	7.0
Unclear	27	3.7
Sample pre-analytical modular system		
Yes	111	15.0
No	627	85.0
Link between LIS and HIS		
Yes	676	91.6
No	62	8.4
Method of reporting		
Electronic via HIS, computer reporting	469	63.6
Printing report	242	32.8
Unclear	27	3.7

ISO, International Organization for Standardization; CAP, College of American Pathologists; LIS, laboratory information system; HIS, hospital information system.

TABLE 2 Median TATs of routine and stat biochemistry analytes (min)

Category and analytes	Pre-examination TAT		Examination TAT		Post-examination TAT	
	N	Median (25th, 75th)	N	Median (25th, 75th)	N	Median (25th, 75th)
Routine biochemistry analyte						
Potassium	558	52.00 (30.00,80.00)	661	88.00 (50.00,124.00)	550	0.00 (0.00,20.00)
Glucose	506	50.00 (30.00,76.00)	600	90.00 (58.25,123.92)	494	0.00 (0.00,20.00)
Total protein	498	53.00 (30.00,80.00)	592	95.00 (60.00,134.50)	489	0.00 (0.00,20.00)
ALT	495	53.07 (30.00,80.00)	587	95.00 (60.00,140.00)	484	0.00 (0.00,20.00)
Magnesium	434	54.00 (30.00,80.00)	521	98.98 (60.00,139.50)	422	0.00 (0.00,20.00)
Triglyceride	489	53.00 (30.50,80.00)	584	98.35 (60.00,141.75)	478	0.00 (0.00,20.00)
CK-MB	427	50.00 (30.00,77.00)	507	85.00 (53.00,120.00)	420	0.00 (0.00,20.00)
cTn	330	41.50 (25.00,65.00)	398	60.00 (40.00,100.00)	323	0.00 (0.00,14.60)
Stat biochemistry analyte						
Potassium	488	20.00 (15.00,30.00)	578	35.00 (24.75,48.00)	477	0.00 (0.00,8.00)
Glucose	466	20.00 (15.00,30.00)	556	36.00 (25.00,48.00)	457	0.00 (0.00,8.00)
CK-MB	409	20.00 (15.00,30.50)	491	39.00 (28.00,50.00)	396	0.00 (0.00,7.00)
cTn	389	20.00 (14.68,30.00)	471	40.00 (29.00,50.00)	379	0.00 (0.00,5.00)
Amylase	454	20.00 (15.00,30.00)	544	35.00 (25.00,48.00)	445	0.00 (0.00,7.50)

The 25th percentile (25th), median, and the 75th percentile (75th) of median TATs were calculated as optimum, desirable and minimum quality specifications. TAT, turnaround time; ALT, alanine aminotransferase; CK-MB, creatine kinase-MB; cTn, troponin.

specimens in this laboratory. In addition, σ scales for the outlier rates can be calculated according to the percentages.⁹ 6σ represents “world class quality”, which is defined as 3.4 defects per million. According to the proposal by Fraser et al.,¹⁰ quality specifications should be classified into three levels: optimum, desirable, and minimum. We therefore

adopted the 25th percentile (25th), median, and 75th percentile (75th) of outlier rates and TATs as optimum, desirable, and minimum quality specifications.¹¹ To compare the indicators of TATs between routine and stat analytes, Mann-Whitney U (M-W) test was adopted. The elements that may influence TAT were considered, including type of

TABLE 3 90th centile TATs of routine and stat biochemistry analytes (min)

Category and analytes	Pre-examination TAT		Examination TAT		Post-examination TAT	
	N	Median (25th, 75th)	N	Median (25th, 75th)	N	Median (25th, 75th)
Routine biochemistry analyte						
Potassium	549	65.00 (40.50,110.00)	659	110.00 (60.00,180.00)	545	0.00 (0.00,25.00)
Glucose	502	67.45 (45.00,110.00)	598	117.00 (60.00,185.24)	491	0.00 (0.00,25.00)
Total protein	494	71.10 (46.00,110.00)	590	120.00 (75.00,200.00)	484	0.00 (0.00,25.00)
ALT	491	73.00 (47.00,110.00)	585	120.00 (78.00,200.00)	480	0.00 (0.00,25.00)
Magnesium	429	77.30 (45.00,116.00)	511	126.00 (80.00,200.00)	418	0.00 (0.00,25.00)
Triglyceride	485	70.00 (45.50,111.00)	582	126.75 (80.00,200.00)	474	0.00 (0.00,25.00)
CK-MB	423	60.00 (43.00,110.00)	504	110.00 (60.00,180.00)	417	0.00 (0.00,25.00)
cTn	329	58.00 (32.00,100.00)	396	85.00 (50.00,145.00)	320	0.00 (0.00,18.00)
Stat biochemistry analyte						
Potassium	482	29.00 (20.00,50.00)	577	50.00 (30.00,64.00)	437	0.00 (0.00,9.50)
Glucose	464	28.00 (20.00,50.00)	555	50.00 (32.00,67.00)	453	0.00 (0.00,9.00)
CK-MB	405	28.00 (19.25,50.00)	405	46.00 (30.00,55.00)	394	0.00 (0.00,9.00)
cTn	384	27.35 (19.00,50.00)	470	50.00 (35.00,69.25)	374	0.00 (0.00,8.00)
Amylase	449	28.00 (20.00,50.00)	543	50.00 (30.00,63.00)	442	0.00 (0.00,9.00)

The 25th percentile (25th), median, and the 75th percentile (75th) of 90th centile TATs were calculated as optimum, desirable, and minimum quality specifications.

TAT, turnaround time; ALT, alanine aminotransferase; CK-MB, creatine kinase-MB; cTn, troponin.

hospital, ISO 15189 or CAP accreditation, methods of sample transportation, sample pre-analytical modular system, link between LIS and hospital information system (HIS) and methods of reporting. The laboratories were grouped based on above six potential impact factors respectively. K-S test was also performed preliminaries to determine the normality of related QIs in various groups. M-W test for two groups and Kruskal–Wallis (K-W) test for three or more groups were employed to evaluate equality of the related QIs. $P < .05$ was defined as the threshold of significance. Bonferroni method was used to adjust α value to further study the factors. The formula was $\alpha = \alpha / [k(k-1)/2]$, led to the $\alpha = 0.05/3 = 0.017$ for three groups and $\alpha = 0.05/6 = 0.008$ for four groups.

3 | RESULTS

A total of 738 participating laboratories submitted their questionnaire, with a response rate of 46.44% (738/1589). Among the laboratories, tertiary hospitals were the major hospitals with a percentage of 80.0% (590/738). For the accreditation status, only 12.1% of the laboratories had been accredited by ISO 15189 or CAP (Table 1). Most (94.4%) laboratories indicated they had employed LIS or HIS, while 97.2% laboratories used barcode systems to ensure the timeliness and trueness of the TAT results. There were 52.3% (386/738), 80.4% (593/738) and 55.3% (408/738) of laboratories declaring that they have monitored pre-examination, examination, and post-examination TATs generally. Approximately 46% of laboratories monitored means of TATs, 24% of laboratories used medians, 17% of laboratories adopted 90th, and 38% of laboratories monitored the outlier rates generally.

Reasons of delayed TATs were also provided by participating laboratories. The first three reasons for delayed TATs in pre-examination were long transportation time (43.8%), large amount of samples (6.1%), and insufficient of transportation staff (5.3%); peak time instruments congestion (43.0%) and large amount of samples (42.7%) were main reasons for examination TAT delaying; LIS/HIS breakdown (16.9%), large amount of samples (15.0%) and instrument failure (14.0%) were major reasons for post-examination TAT delaying.

3.1 | Nine QIs of TATs for routine and stat tests

As shown in Table 2, the medians of pre-examination, examination, and post-examination TATs of routine and stat biochemistry tests varied among different analytes. For routine biochemistry analyte, the median TATs of cTn and CK-MB were lower than that of other analytes, while magnesium and triglyceride were slight higher. The medians of post-examination TATs in most laboratories were 0 min. M-W test showed that significant differences existed between median TATs of routine and stat analytes in three time intervals ($P < .05$). As shown in Table 3, the 90th of pre-examination, examination, and post-examination TATs of routine and stat biochemistry tests were diverse from different biochemistry analytes. The P value of M-W test between 90th TATs of routine and stat analytes in three time intervals was less than .05.

Outlier rates were considered as the number of specimens of each analyte exceeding the goal TAT set by a laboratory dividing by the total number of specimens in this laboratory. The goal TATs of biochemistry analytes set by laboratories are described in Table 4. Distributions of goal TATs among different analytes were similar and stat tests presented lower time than routine ones (M-W test, $P < .05$). The outlier rates of TATs were calculated according to the goal TATs

TABLE 4 The goal TATs of biochemistry analytes (min)

Category and analytes	Pre-examination TAT		Examination TAT		Post-examination TAT	
	N	Median (25th, 75th)	N	Median (25th, 75th)	N	Median (25th, 75th)
Routine biochemistry analyte						
Potassium	552	60.00 (40.00,120.00)	628	120.00 (60.00,240.00)	568	0.00 (0.00,30.00)
Glucose	498	60.00 (56.00,120.00)	566	120.00 (86.75,240.00)	506	0.00 (0.00,30.00)
Total protein	489	60.00 (60.00,120.00)	561	180.00 (90.00,240.00)	499	0.00 (0.00,30.00)
ALT	484	60.00 (60.00,120.00)	553	180.00 (100.00,240.00)	495	0.00 (0.00,30.00)
Magnesium	423	60.00 (60.00,120.00)	481	180.00 (112.50,240.00)	432	0.00 (0.00,30.00)
Triglyceride	478	60.00 (60.00,120.00)	550	180.00 (113.75,240.00)	489	0.00 (0.00,30.00)
CK-MB	419	60.00 (50.00,120.00)	480	120.00 (60.00,240.00)	431	0.00 (0.00,30.00)
cTn	323	60.00 (30.00,120.00)	376	120.00 (60.00,180.00)	334	0.00(0.00,20.00)
Stat biochemistry analyte						
Potassium	475	30.00 (20.00,60.00)	551	60.00 (40.00,90.00)	487	0.00 (0.00,10.00)
Glucose	455	30.00 (20.00,60.00)	530	60.00 (40.00,90.00)	468	0.00 (0.00,10.00)
CK-MB	398	30.00 (20.00,60.00)	467	60.00 (40.00,120.00)	408	0.00 (0.00,10.00)
cTn	379	30.00 (20.00,60.00)	450	60.00 (40.00,103.75)	391	0.00 (0.00,10.00)
Amylase	444	30.00 (20.00,60.00)	518	60.00 (40.00,120.00)	456	0.00 (0.00,10.00)

TAT, turnaround time; ALT, alanine aminotransferase; CK-MB, creatine kinase-MB; cTn, troponin.

above, which presented as both % and σ (Table 5). Among these analytes, outlier rates of CK-MB and cTn were lower and achieved quality more than 4σ , while potassium had higher outlier rates. M-W test suggested there were no significant differences between outlier rates of routine and stat tests for different analytes (P value $>.05$ for each analyte).

3.2 | Potential impact factor analysis

K-S test indicated that the distribution of each group was abnormal ($P<.05$). Table 6 describes the results of non-parametric test (M-W test for two groups and K-W test for three or more groups). Bonferroni method was used to adjust α value to further study the

factors, $\alpha=0.05/3=0.017$ for three groups and $\alpha=0.05/6=0.008$ for four groups. The results showed that for routine tests: 1) the medians of examination TATs, 90th of pre-examination, and examination TATs of tertiary hospitals were longer than that of non-tertiary hospitals ($P<.05$); 2) ISO 15189 or CAP accreditation hospitals had longer TATs in medians of examination, 90th of pre-examination, and examination TATs than non-accredited hospitals ($P<.05$). For pre-examination phase, 90th TATs of nurse transportation in routine biochemistry were shorter than laboratory/professional staff transportation ($P<.05$). For post-examination phase, TATs of laboratories linking between LIS and HIS and computer reporting showed a better performance ($P<.05$). For stat tests, the results of factors analysis were parallel with routine ones.

TABLE 5 TAT outlier rates of routine and stat biochemistry analytes

Category and analytes		Pre-examination TAT		Examination TAT		Post-examination TAT	
		N	Median (25th, 75th)	N	Median (25th, 75th)	N	Median (25th, 75th)
Routine biochemistry analyte							
Potassium	%	529	1.39 (0.00,7.05)	591	0.31 (0.00,2.14)	531	0.00 (0.00,0.00)
	σ	529	3.70 (2.97,6.00)	591	4.24 (3.52,6.00)	531	6.00 (6.00,6.00)
Glucose	%	479	0.73 (0.00,5.00)	539	0.09 (0.00,1.49)	478	0.00 (0.00,0.00)
	σ	479	3.94 (3.14,6.00)	539	4.63(3.67,6.00)	478	6.00 (6.00,6.00)
Total protein	%	471	0.79 (0.00,4.42)	535	0.13(0.00,1.62)	472	0.00 (0.00,0.00)
	σ	471	3.92 (3.20,6.00)	535	4.50 (3.64,6.00)	472	6.00 (6.00,6.00)
ALT	%	467	0.67 (0.00,4.52)	531	0.10 (0.00,1.43)	466	0.00 (0.00,0.00)
	σ	467	3.97 (3.19,6.00)	531	4.59 (3.69,6.00)	466	6.00 (6.00,6.00)
Magnesium	%	406	0.83 (0.00,7.21)	455	0.06 (0.00,2.06)	404	0.00 (0.00,0.00)
	σ	406	3.90 (2.96,6.00)	455	4.74 (3.54,6.00)	404	6.00 (6.00,6.00)
Triglyceride	%	460	0.83 (0.00,4.55)	525	0.06 (0.00,1.69)	458	0.00 (0.00,0.00)
	σ	460	3.90 (3.19,6.00)	525	4.76 (3.62,6.00)	458	6.00 (6.00,6.00)
CK-MB	%	397	0.53 (0.00,6.32)	455	0.00 (0.00,2.04)	401	0.00 (0.00,0.00)
	σ	397	4.06 (3.03,6.00)	455	6.00 (3.55,6.00)	401	6.00 (6.00,6.00)
cTn	%	311	0.49 (0.00,7.69)	360	0.00 (0.00,2.98)	312	0.00 (0.00,0.00)
	σ	311	4.08 (2.92,6.00)	360	6.00 (3.38,6.00)	312	6.00 (6.00,6.00)
Stat biochemistry analyte							
Potassium	%	459	0.50 (0.00,6.00)	529	0.00 (0.00,2.80)	459	0.00 (0.00,0.00)
	σ	459	4.08 (3.05,6.00)	529	6.00 (3.41,6.00)	459	6.00 (6.00,6.00)
Glucose	%	442	0.19 (0.00,5.35)	507	0.00 (0.00,2.42)	442	0.00 (0.00,0.00)
	σ	442	4.39 (3.11,6.00)	507	6.00 (3.47,6.00)	442	6.00 (6.00,6.00)
CK-MB	%	383	0.00 (0.00,5.71)	443	0.00 (0.00,2.44)	381	0.00 (0.00,0.00)
	σ	383	6.00 (3.08,6.00)	443	6.00 (3.47,6.00)	381	6.00 (6.00,6.00)
cTn	%	367	0.00 (0.00,6.38)	428	0.00 (0.00,3.80)	365	0.00 (0.00,0.00)
	σ	367	6.00(3.02,6.00)	428	6.00 (3.27,6.00)	356	6.00 (6.00,6.00)
Amylase	%	427	0.00 (0.00,6.25)	494	0.00 (0.00,2.95)	430	0.00 (0.00,0.00)
	σ	427	6.00 (3.03,6.00)	494	6.00 (3.39,6.00)	430	6.00 (6.00,6.00)

Percentage (%) of outlier rate was considered as the number of specimens exceeding the goal TAT set by a laboratory dividing by the total number of specimens in this laboratory. σ scales for the outlier rates can be calculated according to the percentages. 6σ represents "world class quality", which is defined as 3.4 defects per million (a).

TAT, turnaround time; ALT, alanine aminotransferase; CK-MB, creatine kinase-MB; cTn, troponin.

TABLE 6 The results of non-parametric test for TAT

		Mann–Whitney/Kruskal–Wallis test, P-Value		
Percentiles of TAT	Group	Pre-examination	Examination	Post-examination
Routine biochemistry				
Median	Type of hospital	.294	.012	.574
	ISO 15189 or CAP accreditation	.149	.001	.384
	Method of sample transportation	0.057	—	—
	Sample pre-analytical modular system	—	.972	—
	Link between LIS and HIS	—	—	.009
	Methods of reporting	—	—	.008
90th	Type of hospital	.033	.001	.586
	ISO 15189 or CAP accreditation	.006	.000	.314
	Method of sample transportation	.023	—	—
	Sample pre-analytical modular system	—	.578	—
	Link between LIS and HIS	—	—	.108
	Methods of reporting	—	—	.005
Stat biochemistry				
Median	Type of hospital	.015	.003	.447
	ISO 15189 or CAP accreditation	.199	.046	.232
	Method of sample transportation	.090	—	—
	Sample pre-analytical modular system	—	.464	—
	Link between LIS and HIS	—	—	.029
	Methods of reporting	—	—	.032
90th	Type of hospital	.001	.000	.417
	ISO 15189 or CAP accreditation	.016	.010	.192
	Method of sample transportation	.078	—	—
	Sample pre-analytical modular system	—	.188	—
	Link between LIS and HIS	—	—	.042
	Methods of reporting	—	—	.056

“—”: not applicable.

TAT, turnaround time; ISO, International Organization for Standardization; CAP, College of American Pathologists; LIS, laboratory information system; HIS, hospital information system.

4 | DISCUSSION

The return rate of this survey was 46.44%, which was lower compared to the national appropriateness of clinical reporting survey in 2013.¹² However, it was obvious higher than the national TAT survey in 2011,⁶ stating the growing attention of laboratories on importance of TAT monitoring. A total of 738 laboratories participated in the EQA program of TAT, with more tertiary, which signified relatively mature laboratory quality management system in China. It was our object likewise to implement the “quality indicators” in these hospitals first and then promote to nationwide. Comparing with the survey in 2011,⁶ this survey contained pre-examination and post-examination phases other than intra-laboratory TAT. Meanwhile, the 90th and outlier rates were added to reflect the tail data.

Percentages of laboratories who monitored examination TATs regularly were much higher than that of pre-examination and

post-examination TATs (80% vs 50%). Laboratories tended to monitor TATs they could control, the factors in pre-examination and post-examination phases were also the main causes of delayed TAT, however.^{13,14} Consequently, TATs across the total testing spectrum should be monitored so as to shorten TAT radically and improve clinical and patient satisfaction. Because of non-Gaussian distribution of TATs, medians, 90th and outlier rates should be monitored simultaneously. Nonetheless, the results of TAT indicators monitoring shows the poor understanding in TAT and TAT monitoring and related training is necessary. Compared with the TAT survey of China launched by NCCL in 2011,⁶ TATs in this survey decreased remarkably. Great progresses had been made in TATs of Chinese laboratories in the past few years.

A Q-Probes study launched by CAP demonstrated that clinicians expected of a shortened TAT than laboratories could provide.¹⁵ Hence, in addition to referring to research at home and abroad, goal TAT setting is a more personalized practice, and laboratories should consider

its own circumstance and communication with the clinic. Compared with outlier rates of examination and post-examination TATs, outlier rates of pre-examination TATs were relatively high, which reflected the insufficient impetus for pre-examination TAT monitoring. More attention should be taken to strengthen the supervision on pre-examination TAT and adopt measures to improve gradually.

In general, tertiary hospitals and accreditation laboratories often had better capacities than non-tertiary and non-accredited ones. Surprisingly, the medians and 90th of pre-examination and examination TATs of tertiary hospitals were higher than that of non-tertiary hospitals, TATs of ISO 15189 or CAP accreditation laboratories were apparently longer than that of non-accreditation laboratories. The conflicting situation may result from the great amount of patients and samples in large-scale hospitals. The workload of transportation and laboratory staff was extremely heavy, and it was required to line up and wait for batch processing in the sample collection, transportation, testing, results check and reporting. In contrast, a lot of waiting time could be eliminated or reduced in small-size hospitals due to the fewer patients, and shorten TATs were deserved.

Multiple studies showed that mechanical pipeline transportation of all types often possessed high uptake rate and relatively low TATs.^{16,17} There were no statistically significant among medians and 90th of pre-examination TATs of different laboratories using various methods of sample transportation in this survey. Whereas, from the distribution of TAT data, laboratories employed mechanical pipeline transportation had lower pre-examination TATs than used laboratory staff and professional staff transportation, which stated the effect of mechanical pipeline transportation in improving pre-examination TATs. Another unexpected result was the higher medians and 90th of examination TATs of laboratories with sample pre-analytical modular system than that without. The reasons may be that laboratories with sample pre-analytical modular system always located in large-scale hospital and suffered heavy workload. Most laboratories had a post-examination TAT as 0min, and M-W test showed that laboratories linking LIS with HIS presented better performance. Meanwhile, post-examination TATs of laboratories adopting computer reporting results were shorter than printing report. The results above suggested the good laboratories practice of using LIS and HIS interface and computer reporting.

Reasons for delayed TATs were also investigated. Some worthy advices were provided for laboratories to implement improvement, for instance, process optimization of sample collection and transportation in pre-examination phase, new instrument purchase in examination phase, valid backup plan for LIS breakdown to send report timely in post-examination phase. Insufficient personnel and large amount of samples were common causes of delayed TAT across the total testing spectrum. In summary, laboratories should monitor the TAT across the total testing spectrum due to the different ways for ameliorating in different phases, seek the reasons for delayed TAT pointedly and ensure timely testing.

There were some flaws exist in our survey. Firstly, TAT was defined as time taken from sample collection to results reception by clinicians, regardless the time from sample requisition to collection and time from results reception by clinicians to take actions. That was because

the difficulty of obtaining these periods of time. Secondly, tertiary hospitals were the main participating laboratories in this survey with high patient-volume, which could not be on behalf of the national level. Finally, it was only a cross-sectional survey, merely involving a 1-week time window, so the results just reflects a one-time situation. Further investigation is needed to show the long-time performance of laboratory TAT in China.

5 | CONCLUSIONS

In spite of the remarkable progresses of TATs in China, there was also great room to improve. Medians and 90th of TATs across the total testing spectrum of some laboratories were extremely large. Therefore, more effort should be made by laboratories to strengthen information system development. In this way, reasons of delayed TATs can be identified through internal longitudinal monitoring and external horizontal comparison, and we can finally achieve continuous improvement for quality of laboratories services.

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DECLARATION OF INTEREST

The authors stated that there are no conflicts of interest regarding the publication of this article.

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