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Assessment of Laboratory Turnaround Time and associated factors for Complete Blood Count and Clinical Chemistry Testes in Emergency and Trauma Hospital, Addis Ababa, Ethiopia.

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This is to certify that the thesis prepared by Betelhem Adbibi, entitled' Assessment of Laboratory Turnaround Time and associated factors for Complete Blood Count and Clinical Chemistry Testes in Emergency and Trauma Hospital, Addis Ababa, Ethiopia**'** and submitted in partial fulfillment of the requirements for Master of Science degree in Clinical Laboratory Sciences (Clinical Laboratory management and quality assurance) complies with the regulations of the University and meets the accepted standards concerning originality and quality.

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Abbreviations /Acronyms

AaBET	Addis Ababa Burn, Emergency and Trauma Hospital
AAU	Addis Ababa University
BUN	Blood Urea Nitrogen
CBC	Complete Blood Count
CCUs	Critical Care Units
CDC	Centers for Disease control and prevention
CI	Confidence Interval
ED	Emergency Department
EDTA	Ethylene Diamine Tetra Acetic acid
ICU	Intensive Care Unit
LIS	Laboratory Information System
LOS	Length of stay
OPD	Out Patient Department
PT	Prothrombin time
RFT	Renal Function test
SPHMMC	St Paul Hospital Millennium Medical College
SST	Serum Separator Tube
TAT	Turnaround Time
WHO	World Health Organization

Abstract

Background: Laboratory tests are an important contributor to treatment decisions in the emergency department. Reporting in acceptable turnaround time (TAT) is a crucial indicator of quality. International standards recommend the laboratory to establish TATs for each of its tests and periodically evaluate whether or not it is meeting the established TAT. However, Addis Ababa Burn, Emergency and Trauma (AaBET) hospital is the first dedicated Emergency and Trauma hospital in Ethiopia, the laboratory's TAT was not determined and assessed.

Objective: To determine laboratory turnaround time and associated factors for complete blood count and clinical chemistry tests at Addis Ababa Burn, Emergency and Trauma hospital.

Method: A prospective cross sectional study was conducted from January to April, 2022. All emergency patient samples that had at list CBC, and/or Chemistry requests and received at the laboratory specimen accessioning room were taken consecutively. Using a structured data collection tool all related information were collected and entered to SPSS version 23 then calculation of major statistics for the time data (in minutes), bivariate and multivariate regression analysis were conducted to assess the relationship between high TAT and the suggested responsible factors. For all statistical tests, $P < 0.05$ was considered significant.

Results: specimen receipt to verification time data were obtained for 4132 tests. Of which, 2309, (55.9%) of them were CBC and 1823, (44.1%) were chemistry) tests. The determined 90th percentile (average) completion time for CBC and chemistry were 105 (53.9) and 457 (257.4) minutes, respectively. More than 28% of the tests did not achieve TAT goals i.e. 60 min for CBC and 240min for chemistry test. Specimen received in; Sundays, night shifts, sample porter not presented, and machine related problems encountered working periods were identified to have significant contribution for delayed TATs.

Conclusion and recommendations: During this initial evaluation, we observed that AaBET hospitals' laboratory test TAT were longer and doesn't comply with the available benchmarks. Improvement in personnel and equipment management may provide effective ways to minimize test result delays in Emergency and Trauma hospital.

Key words: *Laboratory turnaround time, Complete Blood Count, Clinical chemistry, Emergency and Trauma hospital,*

1. Introduction

1.1. Background

Prolonged turnaround time (TAT) of STAT emergency samples is the single most common cause of complaints about laboratory services all over the world [1].Millions of deaths that result from injuries represent only a small fraction of those injured. Tens of millions of people suffer injuries that lead to hospitalization, emergency department (ED) or general practitioner treatment, or treatment that does not involve formal medical care [2]. Patient overload in ED with the resultant shortage of beds has expectedly increased the demand for shorter TAT for Lab tests [3].

TAT is an important parameter for the laboratory as well as for the hospital assessing the laboratory service. Measuring TAT starts with establishing a definition of TAT for the specific institution. A single definition of TAT is not adequate for all types of test or setting. The most appropriate TAT is starting from the time a physician orders a test to the time he gets back the reports [4]. However, most laboratories restrict their definition of TAT to intra-laboratory activities, arguing that other factors are outside their direct control and that timing data for extra laboratory activities are not readily available [3].

In acute care settings such as intensive care unit (ICU) or ED, arterial blood gas profiles, complete blood counts (CBC), partial thromboplast in times, and measures of magnesium levels and basic metabolic panel, which measures glucose, calcium, electrolytes, and analytes related to kidney function (RFT), is commonly ordered in hospital emergency rooms because its results can indicate several acute problems, including kidney failure, insulin shock or diabetic coma, respiratory distress, or heart rhythm changes [5].

ED overcrowding and long waiting times are a major concern for health care system and are not relieved yet [6]. ED physician's time with patients is decreasing as the health care system tries to accommodate more patients per hour. It is only natural that ED physicians try to optimize the effectiveness of their environment while minimizing the impact on their time. They perceive, and have perceived for decades, that laboratory test TAT hinders this process [1].

Clinical laboratories that service ED and other critical care units (CCUs) must provide accurate, precise, and rapid test results for the management of medical emergencies [7]. Although the length of stay (LOS) is influenced by several factors, different studies have shown that reducing the time in receiving the results of lab tests in the ED has a significant impact on reducing the overall waiting time for the patients [8]. However, many hospital laboratories have difficulty providing prompt service to the ED because of problems with logistics, staff shortages, and technical factors relating to the performance of some tests [9]. Analyzing outliers in TAT in a lab gives insight of causes delay in TAT and the areas need improvement [4].

The introduction of a mechanical tube system and automated instrumentation, launching point-of-care laboratories, increasing the number of personnel, interface laboratories instruments using computerization software's, to review results and to deliver reports to clinicians are more frequently recommended methods to improve laboratory TAT in emergency and critical care units[10].

Trauma panels; such as electrolytes, urea, creatinine and complete blood count (CBC) are frequently ordered tests for critical care patients and optimized critical care requires real-time laboratory results for evidence based medicine clinical decisions [11]. In Ethiopia, literature on reasonable or acceptable TAT performance for critical testing is scant. Therefore, this study aims to assess emergency and critical caring hospitals laboratory TAT performances using CBC, RFT and Electrolytes tests as an example.

1.2 Statement of the Problem

Over 80% of laboratories receive complaints about TAT, yet there is little agreement among clinicians on what constitutes acceptable TAT. Service to the ED is a particular source of dissatisfaction with 87% of institutions reporting complaints [12].

Despite technical, transport and information technology improvements in recent decades, TAT continue to be a cause of customer dissatisfaction with the laboratory service. Laboratory staff can feel frustrated when the effects of improvements in intra-laboratory TAT are diluted by pre-analytical and post-analytical factors seemingly outside their control. Observations such that 45% of the results for urgent laboratory tests requested by the ED were never accessed or were accessed too late do little to encourage efforts by the laboratory to provide a faster service [10].

In 2014 WHO reported that, every day the lives of more than 14 000 people are cut short as a result of injury. Among the causes of injury are acts of violence against others or one self, road traffic crashes, burns, drowning, falls, and poisonings. More than 5 million people die each year as a result of these injuries which accounts for 9% of the world's deaths [2].In USA approximately 140 million patients are presenting at EDs annually [13].Results of laboratory tests ordered in the ED are an important factor in patient management decisions. The timely return of result can significantly impact faster therapeutic intervention and better patient outcomes [6].

Overcrowding and prolonged length of stay (LOS) in ED are an increasing problem in most public hospitals [3]. Even though, there are few statistical reports on analyzing the factors that affect this overcrowding problem, considerably low laboratory efficiency in ED might contribute to the ED overcrowding [14].Study finding in USA reviled that even very modest decreases in the laboratory TAT can have appreciable impact on ED LOS [6].

The contributions of laboratory tests and services as an essential component and partner in health systems remain under-recognized. Despite the extensive role of laboratory medicine in informing medical decision-making, spending on laboratory services accounts for only 2.3% of national healthcare spending and 2% of Medicare expenditures [5]. However, developing of processes/technologies with the potential to drive further efficiencies and reduce laboratory TAT needs appropriate resources [6].

In Ethiopia, study from Gondar and Addis Ababa hospitals also found that poor TAT achievements were reported [15, 16]. These previous articles are mainly focused on evaluation of performance of TAT at general hospitals. Published data particularly on emergency hospitals are lacking thus this research may provide valuable information regarding emergency and trauma hospital laboratory test result TAT.

1.3 Significance of the study

Particularly in critical care settings; Hematocrit or hemoglobin monitoring, measurements of electrolytes (sodium, potassium, and chloride), blood urea nitrogen and creatinine are all considered desirable. Thus assessment of laboratory performance by measuring of turnaround time at emergency and trauma hospital is essential to develop timeliness of care in order to minimize unnecessary delays that can result in emotional or physical harm in to patients. In addition, this study will provide valuable information for physicians and other clinicians, to recognize if the laboratory TAT threshold is posing significant risk to patient safety, which helps to make early decision in to patient management procedure. Patients and/or their relatives could use this information to prepare themselves in terms various resources (i.e. time, finance). Identifying the causes of delay in emergency test TAT could help for laboratory professionals and policy makers, to develop a strategy that reduces TAT toward a desired goal. Furthermore, this study finding will be used as baseline information by other researchers who would like to conduct a research on this critical problem.

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2. Literature review

2.1 Turnaround Time and Associated Factors

Laboratory medicine has an essential role in risk management and provides value across the continuum of patient care. In addition to providing objective data about patient health, laboratory medicine enables to manage acute health conditions. In acute care settings such as the intensive care unit (ICU) or the ED, frequent laboratory testing can be used to monitor quickly and accurately an individual's status and response to medical interventions [5].Unhappiness with TAT remains a problem today and factors may vary depending upon the infrastructures of the institution, degree of automation, and experience and attribution of the employee [1]

Factors affecting TAT in the clinical laboratory of the Kathmandu University Hospital, Nepal were assessed using a cross-sectional, descriptive and observational study in the year 2017. When 24644 patients' reports were analyzed for TAT and affecting factors, 2434 (9.8%) of them had prolonged TAT in comparison to predefined TAT. However, only 2010 out of 24644 patients have reasons documented on test report form for stretched TAT. The major reasons for delay in laboratory reports were due to the time burnt out to fix the pre-analytical errors created by other departments and cash unit alone was the major factor with highest degree of error (48.4%) in total testing process [17].

From 2011 to 2012, another retrospective cross-sectional study was conducted at Shree Krishna Hospital, India to analyze TAT and reason for delay in accredited hematology and chemistry laboratory. Total 102331 samples were received during study period, out of which 6989 (6.8%) sample were reported out of range for acceptable TAT. Most common delay was noted during lunch breaks, 4139 (59.22%) and early mornings 2050 (29.33%). Thus, less staff members during these time and increase in workload at this time could well be a reason for delay in TAT at these times of the day [13].

A cross-sectional hospital-based study was conducted during November and December, 2014 in Iran hospital ED. During the study period, TATs of 1328 hematology and chemistry tests were calculated to measure TATs in a hospital ED. Approximately 21.9%, 30.1% and 47.8% of the tests were done during the morning, midday, and night shift, respectively. The findings were, mean total TAT for all the tests in the morning shift was significantly longer than in the night

shift (2.8 - 1.2 hours vs. 2.0 - 0.7 hours), the mean total TAT of all the tests ranged from 1.3 to 3.1 hours, with a median of 2.0 hours, 90% of the tests were completed within 3.5 hours, and total TATs of chemistry tests were significantly longer than those of hematology tests [18].

In 2014 a cross-sectional study was conducted at Shanghai hospital EDs to analyze the relationship between the laboratory efficiency and the ED overcrowding through evaluating a total of 17 regional and national hospital ED and central laboratories by TAT levels. The major finding was, TAT at ED laboratories were longer than those at central laboratories based on this investigators concluded that, ED laboratories have not yet approached a level to share the burden of patient flow at emergency department and that might contribute to the ED overcrowding [14].

Another a before-and-after study was conducted by Singer J. *et al* to determine the impact of a Stat laboratory on ED LOS after introducing a Stat lab within the central laboratory demonstrated the following. Percentage of a test TAT of less than or equal to 30 minutes was significantly increased for all available tests after introducing the Stat lab and median ED LOS was significantly reduced for admitted patients from 466 (337–649) minutes before to 402 (296–553) minutes after implementing the Stat lab [19].

In Kenya, the average therapeutic TAT for hematology was 20.3 ± 0.331 hours (95% CI) while that for biochemistry was 22.2 ± 0.346 hours (95% CI). The processing step that caused the biggest delay in TAT was 'Printing, sorting and dispatch' of results. The mean time taken by this step for hematology and biochemistry was 8.3 ± 1.29 hours (95% CI) and 8.5 ± 1.18 hours (95% CI) respectively. Transportation of samples was the most efficient process with the mean transportation time for both hematology and biochemistry tests being around 10 minutes. Analysis took significantly longer with biochemistry when compared with hematology, which was the primary contributor to the significantly longer TAT overall for biochemistry compared with hematology tests [20].

2.2 Optimal Turnaround Time for the Emergency Laboratory

A national survey was conducted across all UK biochemistry laboratories in 2017. Each participant was asked to provide a professional opinion on what TAT would pose an unacceptable risk to patient safety for each departmental (ED, OPD, IPD, GP and Wards) category. TAT was also defined as being the time from receipt to reporting for core

investigations (i.e. Urea & Electrolyte and LFT). The consensus optimal TAT for the ED was <1 hour (h) with >2 h considered unacceptable. The times for GP and OPD were <24 h and >48 h and for Wards <4 h and >12 h, respectively [21].

According to Hawkins R., article review on laboratory TAT, a 90% completion time (sample registration to result reporting) of <60 minutes for common laboratory tests is suggested as an initial goal for acceptable TAT. Expectations of ED clinicians and laboratory staff TAT for Hgb and K, were 20 – 30 minutes and 55 – 60 minutes, respectively [10]. Another finding showed that, more than 93% of Hgb results have met the TAT target mean (30 minutes) set for hematology [22].

Anther cross-sectional study measured and analyzed TAT for hemoglobin, serum potassium, and prothrombin time by using two models to identify the primary causes of laboratory TAT delay in Iran hospital ED. Data for 551 tests showed, the TATs for hemoglobin, serum potassium, and prothrombin had a median of 170, 225, and 195.5 min, respectively. Overall conclusion were, the differences between reported TATs and Q-Probes goals (45 min) suggest that much needs to be done to improve TATs in the institution [24].

In Nigeria a cross-sectional paper based survey was conducted to assess a physician ideal expectation and experience with laboratory TAT in emergency situations. Of the total 104 participants who were asked about their ideal TAT expectation in critical care situations, 91.3% of the respondents considered the ideal TAT for their laboratory results should be less than 2 hours, while 8.7% consider the ideal to be 2-4 hours. However, in the emergency situations 47%, of the respondents reported a TAT of less than 2 hours for tests requested from the emergency room compared to the 20.4%, 23% and 14% of the respondents who experienced a TAT of less than 2 hours for tests requested from other emergency situations like special care baby unit, ICU and dialysis unit, respectively [23].

2.3 Turnaround Time and Clinical Outcomes

In 2018, two studies were conducted by Kaushik N. et al to examine the effect of rapid TAT of laboratory tests on ED LOS using large, US-based retrospective analysis of Electronic Health Records. First study uses retrospective data from 486 US hospitals and health systems while a second retrospective analysis was conducted using a single hospital records. This retrospective

analysis of real world patient data from 486 US hospitals indicated a 0.50 minute decrease in ED LOS with every 1-minute decrease in laboratory TAT. They confirmed these results for data from a single site, where patients were segmented based on acuity; found that a 1-minute decrease in laboratory TAT for patients across acuities 1 – 4 resulted in 0.37 - 0.91minute reductions in ED LOS, respectively, with the greatest gains for the highest-acuity patients. In conclusion reduction in laboratory TAT ED could potentially accept additional patients [6].

2.4 Methods to Improve Turnaround Time

Health care stakeholders are spending larger resources to redesign and improve the health care delivery system. For example the Chinese government launched a reform plan in 2009, which included spending approximately 125 billion US$ to fund a public health provision. With this funding, equipment at medical facilities, infrastructure development, and training sessions has been innovated and the medical environment is gradually improved [25].

There is great emphasis on providing quick and accurate laboratory test results for individuals in critical care settings. One commonly used method of achieving short TATs is STAT testing, which refers to the sequence of events to obtain urgently needed test results promptly. Many hospitals maintain designated STAT laboratory space to meet urgent testing needs, usually located next to operating rooms, critical care units, or the emergency department [5]

A baseline and 2-arm intervention, prospective, observational study was performed on the data for patients who had at least 1 of 5 laboratory tests (CBC count, chemistry panel, PT, troponin, or blood culture) performed as part of their care. The purpose of this study was to improve the quality of care in an ED as by reducing total TAT for laboratory result reporting after implementing two phase intervention. They have shown that placing laboratory personnel in the ED to collect specimens (intervention 1) decreased the laboratory total TATs for 4 tests, and the time to be seen by an ED physician. In addition, when a technologist in the laboratory dedicated to receiving ED samples was added in intervention 2, the total TATs decreased further [26].

Equipment factors
- Number
- Technology
- Output

Personnel factors
- Number
- Qualification
- Competency

Test method factors
- Principle
- Feasibility
- Output

LIS factors
- Technology
- Complexity
- Features

Prolonged laboratory test TAT

Supply factors
- Stock out
- Resource shortage

Institution setting factors
- Critical
- Non critical
- Work load

Clint factors
- Compliant
- Trust lost
- Longer stay
- Quality care?

Figure 1. Study conceptual work adopted from related literatures

3. Objectives

3.1. General objective

To determine laboratory turnaround time and associated factors for complete blood count and clinical chemistry tests at Addis Ababa Burn, Emergency and Trauma hospital from January to April, 2022.

3.2. Specific objectives

- To determine laboratory turnaround time for complete blood count and clinical chemistry tests.
- To assess associated factors of laboratory turnaround time for complete blood count and clinical chemistry tests result delay.

4. Hypothesis

Laboratory turnaround time for complete blood count and clinical chemistry tests at Addis Ababa Burn, Emergency and Trauma hospital laboratory may not be different with turnaround time established by the AaBET hospital laboratory.

5. Materials and methods

5.1. Study area

Addis Ababa Burn Emergency and Trauma (AaBET) Hospital is a major and first trauma center in Addis Ababa, Ethiopia. It was established in 2015 as part of St. Paul's hospital millennium medical college (SPHMMC). AaBET hospital is teaching hospital that provides care to the residents of Addis Ababa and all over Ethiopia. The hospital provide health care service in specialties namely; orthopedics, neurosurgery, plastic and reconstructive surgery, burn, emergency and critical care. Annually, AaBET hospital has approximately 10,000 – 20,000 emergency visits to the hospital and provides an emergency and outpatient services and elective and emergency surgeries of the respective departments [27].

AaBET hospital laboratory organized in to Emergency, Blood bank, Microbiology and Core/Central laboratory. A total of 21 laboratory technologist and 5 supportive staff are available. The Core-Lab acts as the main laboratory of the hospital, processing the majority of the exams requested by the hospital respective departments. It processes on average 150 (≈ 80 – 100 hematology and ≈ 30 – 50 chemistry) tubes per day. The laboratory instrument used for CBC analysis is the Sysmex XN-550 Hematology Analyzer (Sysmex Corp, Kobe, Japan) with a manufacturer-reported throughput of 60 specimens per hour [28]. The Cobas c311 (Roche Diagnostics, Germany) analyzer, which performs 300 photometric and 150 ISE measurements per hour is also available for chemistry measurements [29]. The Polytech Laboratory Information System (Comp Pro Med, Inc., USA) is used for information management and these analyzers are interfaced with this information management system [30].

5.2. Study design and period

A prospective cross-sectional study was conducted from January to April, 2022.

5.3. Population

5.3.1. Source population:

All Hematology and clinical chemistry test requests at AaBET hospital were considered as the source population.

5.3.2. Study Population:

Study populations were Complete Blood Count and clinical chemistry test requests of emergency patients received by the laboratory during the study period.

5.4. Inclusion and exclusion criteria

5.4.1. Inclusion criteria

All hematology (CBC) and/or chemistry (organ function, electrolyte and/or glucose) tests requests at emergency and trauma departments of AaBET hospital during the study period were included in this study.

5.4.2. Exclusion criteria

Test requests that fulfill sample rejection criteria (such us; insufficient hemolysed, clotted specimen(for CBC), mislabeled sample and test request form), tests for medical checkup purposes only, test from rerun sample and test results that are not released within 24 hours of reception were excluded.

5.5. Study variables

5.5.1. Dependent variables:

- Laboratory turnaround time.

5.5.2. Independent variables:

- Specimen reception week days and shifts of day variations,
- Daily work loads
- Type and number of additional (other) test requested,
- Computer or software related problem,
- Equipment related problem
- Supportive staff/runners availabilities
- Technologist shortage

5.6. Sample size and Sampling method

5.6.1. Sample size

The sample size of this study was the total number of 4132 test requests ordered for the CBC and clinical chemistry tests during the study period were included.

5.6.2. Sampling Method

Since AaBET is established to provide a fully dedicated emergency and trauma service in this country, we had selected this study site purposefully. All samples for CBC and chemistry test requests that fulfill the inclusion criteria were conveniently selected, and the time data were collected accordingly.

5.7. Measurement and Data collection

5.7.1. Data collection procedure

During each days of study period two data collectors were employed (one at sample reception and one at core lab). Structured data collection tools i.e. Sample and test request information collection form, and daily work area evaluation or observational checklists, were developed and distributed to these trained data collectors [annex II, III]. Blood samples for CBC and/or clinical chemistry test arrived at the laboratory specimen reception unit, time data and any possible factors for rejection were recorded. In addition the laboratory daily work related conditions like adequacy of work area, equipment and reagent, internal quality controls, staff number, and other important events were observed and documented for 24hours of a day. Principal investigator of this study with the laboratory quality manager extracts every 24 hours patient records that contain the required test and time related information from the laboratory information system then aligns to the pre-collected data.

5.7.2 Measurement of laboratory turnaround time

A) Laboratory work processes and data recording points

I) Sample accessioning time recording: the laboratory has two reception points; every sample received at the receptions I has a request form provided together with it on the other hand at the reception II patient with request form are presented and samples are collected. Patient

information and ordered test are recorded on the Polytech Laboratory Information System (Comp Pro Med, Inc., USA) database. The sample are evaluated according to specimen acceptance criteria then labeled with printed barcode that have specimen reception time and the accessioning time were recorded at these points.

II) Workflow for samples and time data points:

All samples with request form are handed over to the core laboratory; where hematology and chemistry tests are performed. Based on the worksheet generated, assigned lab staff at specimen processing area would then be able to segregate samples with and without serology test requests and processes accordingly. At this work area the second time data or specimen transportation time that is, from specimen reception/collection point to specimen processing area was recorded.

III) CBC and chemistry test analysis

Following these above procedures, for chemistry test analyses the samples are then loaded onto the analyzer manually on Cobas c311 (Roche Diagnostics, Germany) analyzer, Similarly for CBC analysis samples are loaded onto sysmex XN-550 (sysmex corporation Kobe, Japan) analyzer. Results are then transmitted to the LIS for validation and any reruns or dilutions for chemistry and/or hematology tests are managed by the lab technologists. Instrument printout test result reports are attached with test request form then placed in secured places and for patients use reports are generated and printed from LIS database. From these two work stations result verification time was recorded.

B) Evaluation of laboratory TAT

For this research purpose, the laboratory total turnaround time was evaluated based on the time from receipt of a sample by the laboratory to the availability of a validated result [31]. The TAT data were extracted from the LIS which captures specimen accessioning to test reporting within the laboratory and 90thpercentile of the total values is generally taken as cutoff values meaning that a time by which 90% of the time the process is completed [4]. This study's TAT analysis finding were compared with the AaBET laboratory bench mark TATs (pre-determined based on consensus or brain storming) and with other recommended TATs for emergency laboratories(< 60min for CBC and <240min for chemistry tests) [21, 22].

5.8. Data Quality Assurance

A) Pre analytical phase

Data collection tools were pre-tested for the accuracy and consistency prior to the actual data collection. Training for all data collectors before the actual work was provided.

B) Analytical phase

The laboratory turnaround time was recorded at each process starting point and end point by using digital clocks and all data collector's time recording device, instrument time and computers designated for LIS time were adjusted to automatic time format and check for similarities at regular intervals. Data completeness was checked manually on spot during the collection process.

C) Post analytical phase

Completion, accuracy and clarity of the collected data were checked carefully on a regular basis. Further, the principal investigator provides feedback and corrections on daily basis to the data collectors.

5.9. Data analysis and interpretation

All data were entered to Microsoft excel for sorting and cleaning then exported to SPSS (Statistical Package for social sciences statistical software) version 23 for analysis. The mean, standard deviation, inter quartile range (IQR) with 90th percentile, time intervals (receipt to verification) in minutes and frequency of the outcome variables were calculated accordingly. To compare the mean of time data during different shifts of days and days of the week, a one-way ANOVA test was used. To test for an association between time delay and any suggested factors that are responsible for prolonged TAT, bivariate association analyses were done. Variables significant ($P < 0.2$) in any of those bivariate association analyses were fit into logistic regression models for multivariate analysis in order to identify factors that were collectively predictive of delayed TAT. Each TAT (> 60min for CBC and >240min for chemistry tests) outcome was modeled separately, and stepwise selection was used to identify the variables with the most predictive value for each outcome. P-values of less than 0.05 were considered as statistically significant.

5.10. Operational definitions

Turnaround time; is the interval between from the time a sample receipt in the laboratory to the time result verification [31].

Receipt in Testing Laboratory;-The date and time a specimen is received in the laboratory that houses the testing site [31].

Verification of Result;-The date and time a result passes all internal laboratory checks and is ready for communication/distribution/release to a patient's physician or other provider [31].

90% Completion TAT;-When receipt-to-report TAT values are arranged from shortest to longest, the 90% completion time represents the TAT within which 90% of tests are completed [4].

Shifts of the day; - A 24 hour time format was used. Each day starting time is 00:00 means 06:00AM local time and Night (00:00 – 06:59) is the first shift followed morning, mid-day, afternoon and evening shifts which have 07:00 – 11:00, 11:01 – 14:00, 14:01 – 17:59 and 18:00 – 23:59 time ranges, respectively.

5.11. Ethical considerations

This study was conducted after ethical approval obtained from Department of Medical Laboratory Science Research and Ethics Review Committee, College of health sciences, Addis Ababa University. The Institutional Review Board of St Pauls Hospital Millennium College approved this study after additional review. Permission also obtained from AaBET hospital laboratory.

5.12. Dissemination of the result

The study finding will be disseminate to Collage of Health Science Department of Medical Laboratory Science, Addis Abba University, AaBET hospital laboratory unit. Manuscript will be submitted for publications in pear review local or international journals and for different organization. In addition, the finding will also be presented on annual conferences of professional societies. The manuscript will be submitted to peer reviewed journals for publication.

6. Result

6.1 characteristics of study samples

During the study period, time data were obtained for 4132 tests ordered by physicians in the emergency and trauma departments of AaBET hospital. Of these, 2309 (55.9%) were hematology tests (CBC) and 1823 (44.1%) were chemistry (Electrolyte, RFT, LFT, Lipid profile and/or others) tests. Of these samples, 79.1% CBC and 78.2% chemistry samples were received at the laboratory specimen accessioning area during working days of the week. In addition, approximately 30% of daily workload CBC and chemistry samples arrived between 11:00 and 14:00 (Mid-day). About 78.1% and 69.2% of CBC and chemistry tests respectively were performed in normal condition (in days which were free of equipment, reagent and personnel related problems). About 38% of the samples were processed during the time when supportive staffs (porters) are unavailable, and more than 63% of the tests were done in days that have more sample flows [Table 1].

Table 1 Frequency and percentage distributions of complete blood count and chemistry test samples within observed characteristics in AaBET Hospital, Addis Ababa 2022. (N= 4132)

Variables		**CBC test sample**	**Chemistry test sample**
Test sample reception days of week	Monday	399(17.3)	285(15.6)
	Tuesday	352(15.2)	292(16.0)
	Wednesday	398(17.2)	297(16.3)
	Thursday	342(14.8)	266(14.6)
	Friday	336(14.6)	285(15.6)
	Saturday	223(9.7)	186(10.2)
	Sunday	259(11.2)	212(11.6)
Test sample reception days of shifts	Night (00:00-06:59)	118(5.1)	97(5.3)
	Morning (07:00-11:00)	526(22.8)	445(24.4)
	Mid-Day (11:01-14:00)	682(29.5)	553(30.3)
	Afternoon (14:01-17:59)	581(25.2)	430(23.6)
	Evening (18:00-23:59)	402(17.4)	298(16.3)
Sample porters are available	Yes	1438(62.3)	1128(61.9)
	No	871(37.7)	695(38.1)
Daily work load	Lees than daily average*	850(36.8)	587(32.2)
	Higher than daily average	1459(63.2)	1236(67.8)
Additional test requested	Yes**	1268(54.9)	1760(96.5)
	No	1041(45.1)	63(3.5)
Daily condition or event	Usual event	1804(78.1)	1261(69.2)
	Not usual**	505(21.9)	562(30.8)

NB:CBC=Complete Blood Count, ***below 50 for CBC and 30 for Chemistry test sample per day, ** serology with chemistry test, Blood group, compatibility test with CBC, ***Chemistry= (QC fail, equipment problem, Weekly and/or Monthly preventive maintenance, staff short), CBC= (Equipment, Computer, and Reagent problems, Service day, staff short).

6.2 Determination of Turnaround Time

The total TATs in minutes, during the different day shifts, and days of the week are shown in table 2.The specimen receipt to verification turnaround time of CBC and Chemistry tests performed by AaBET hospital laboratory during a four month study period have showed 105 and 457 minutes 90% completion time, respectively. In this laboratory TAT is quite variable some tests take less than 10 minutes to complete, whereas others take several hours (maximum for, CBC 6 and chemistry 24 hours). Overall, the mean (±standard deviation /SD) total TAT for CBC and chemistry were, 53.9 (±53.4) and 257.4 (±287.9), with a median (inter quartile range /IQR) of 37 (22-66), and 173 (110-267) minutes, respectively [table 2].

AaBET hospital laboratory has planned that to complete 90% of CBC and chemistry tests with in 60min (1hr) and 240min (4hrs), respectively. However, according to this study assessment finding only 72.0% of CBC and 69.9% of chemistry tests are completed within pre-determined TAT. Most CBC test delays (13.9%) were limited to the first 30 minutes followed by 6.7%, 4.0% and 3.4% were delayed within 30 – 60, 60 – 120, and more than 120 minutes, respectively. From the total chemistry test results 192 (35.0%), 185 (33.8%) and 171 (31.2%) delays were limited to the first 1 hours and followed by 1 – 4 and 4 – 24 hours, respectively [figure 2].

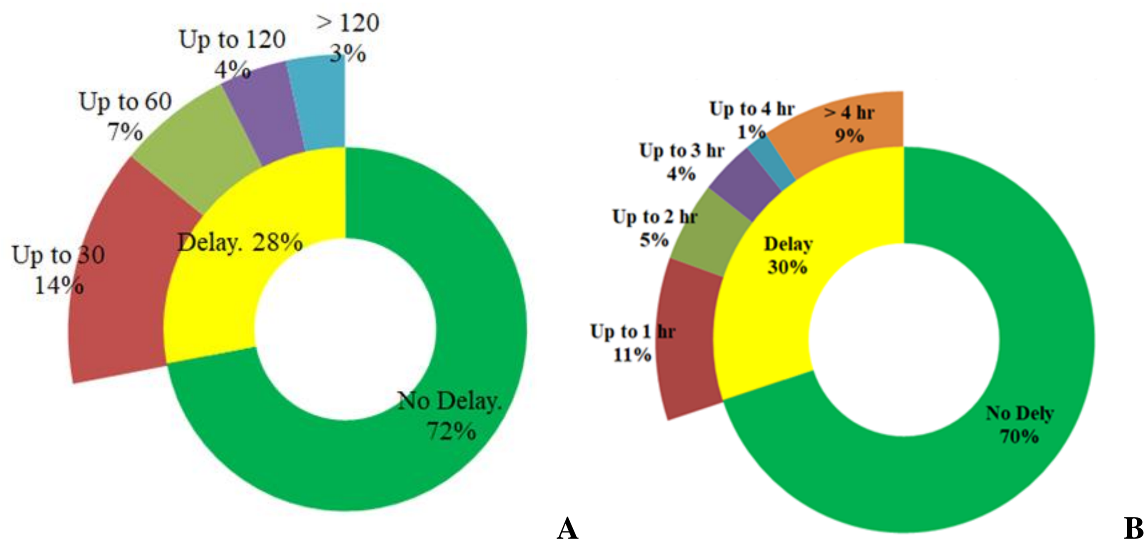

Figure 2 Breakup report for delayed TAT for A Complete Blood count and B Chemistry tests at AaBET hospital Laboratory 2022.

Table 2 Statistics for complete blood count and chemistry tests TAT in Minute from receive to verification according to the Shift and Day of the week in AaBET hospital, Addis Ababa 2022.

Test and TAT	**CBC test TAT per min**			**P value**	**Chemistry test TAT per min**			**P value**
	Mean (SD)	**Median (IQR)**	**90thtime**		**Mean (SD)**	**Median (IQR)**	**90thtime**	
Day of the week				0.245				0.002
Monday	54.6 (57.6)	36 (22-67)	101		238.3(254.7)	169 (102-271)	394	
Tuesday	53.5 (57.6)	36 (22-58)	110		229.9(249.5)	158 (106-240)	430	
Wednesday	58.5 (54.0)	41 (24-77)	112		249.0(284.1)	170 (102-272)	410	
Thursday	49.9 (51.8)	32 (20-59)	107		272.0(315.8)	182 (110-261)	509	
Friday	52.3 (47.8)	37 (22-66)	104		260.2(287.5)	169 (106-261)	502	
Saturday	49.5 (47.7)	36 (22-59)	99		338.8(365.0)	210 (148-301)	949	
Sunday	57.5 (52.9)	43 (24-71)	110		239.5(260.7)	154 (108-268)	410	
Shift of day				0.001				0.001
Morning	50.6 (50.4)	34 (21-61)	106		217.5(263.8)	141 (95-216)	358	
Mid-Day	53.4 (53.0)	36 (22-67)	101		228.8(221.1)	187 (137-247)	301	
Afternoon	51.5 (53.7)	35 (22-60)	100		316.6(363.3)	171 (91-369)	977	
Evening	56.9 (49.4)	44 (26-72)	101		273.0(292.2)	175 (124-248)	696	
Night	72.8 (72.7)	49 (28-105)	145		293.7(293.5)	230 (109-367)	532	
Total	**53.9 (53.4)**	**37 (22-66)**	**105**		**257.4 (287.9)**	**173 (110-267)**	**457**	

NB:CBC=Complete Blood Count, TAT=Turnaround time, SD=Standard Deviation, IQR=Inter Quartile Range, 90th = 90% completion time in minutes.

6.3 Factors associated with delay in Turnaround Time

Besides collecting time data each daily activity, events and/or incidents observed in the laboratory were noted, documented and analyzed. Less number of technologists not assigned at specific work station and unavailability of supportive staff to transport specimen during non-office working hours (night, weekends, and holydays), batch testing (more in clinical chemistry), and high sample flow in mid-day were among the observed daily conditions.

The determined CBC TAT was mainly affected by shifts of days than days of week differences. Among the weekdays, the longest CBC TAT in [mean ± SD; median (IQR25th-75th)] was [58.5 ± 54.0; 41 (24-77)] on Wednesdays, and the shortest TAT [49.5 ± 47.7; 36 (22-59)] was on Saturdays. However, non-significant average TAT difference were observed between weekdays ($P>0.05$). According the shifts of the day, relatively a smaller number of CBC samples were received during night shifts (00:00 to 06:59) also the longest TAT [72.8 ± 72.7; 49 (28-105)],with 145min 90thpercentile were recorded in to these samples. Overall, between shifts significant ($P<0.05$)CBC testing average TAT variations were observed [table 2].

As indicated in Table 3, in the bivariate logistic regression analysis, different weekdays and days of shifts, porter unavailability, and CBC test requesting without blood group and/or compatibility tests were significantly associated ($p < 0.05$) with prolonged CBC TAT. After adjustment using multivariate logistic regression analysis, CBC tests received in evenings and nights shifts, and CBC test requested without blood group and compatibility testing were identified as independent predictors of delayed CBC test result. Significantly a higher proportion (40.7%) of CBC test results delay were observed in samples received during night shifts (AOR = 2.32; $p < 0.001$) followed by in evening shifts (32.1%) (AOR = 1.58; $P = 0.03$) as compared to the first (morning) shifts, In addition, CBC test requested without BG and/or cross-match tests showed significantly (AOR = 1.57, $P = 0.009$) higher proportion of result delay as compared to samples received for CBC, BG and cross-match tests.

Table 3 Association of independent characteristics with magnitude of TAT delay among complete blood count test performed in AaBET hospital, Addis Ababa 2022.

Characteristics		**TAT Delay N/%**	**Bivariate regression**		**Multivariable regression**	
			COR (95% C.I.)	**P-value**	**AOR (95% C.I.)**	**P-value**
Days of week	Monday	115/28.8	1		1	
	Tuesday	82/23.3	0.75 (0.54-1.04)	0.086	0.74 (0.53-1.03)	0.071
	Wednesday	129/32.4	1.18 (0.88-1.60)	0.272	1.18 (0.87-1.61)	0.277
	Thursday	84/24.6	0.80 (0.58-1.12)	0.192	0.78 (0.56-1.08)	0.139
	Friday	98/29.2	1.02 (0.74-1.40)	0.918	1.00 (0.72-1.37)	0.976
	Saturday	52/23.3	0.75 (0.51-1.10)	0.138	0.71 (0.49-1.05)	0.084
	Sunday	87/33.6	1.25 (0.89-1.75)	0.195	1.23 (0.88-1.73)	0.230
Days of shifts	Morning	134/25.5	1		1	
	Mid-Day	192/28.2	1.15 (0.89-1.48)	0.299	1.18 (0.91-1.53)	0.219
	Afternoon	144/24.8	0.96 (0.73-1.27)	0.791	1.04 (0.78-1.37)	0.807
	Evening	129/32.1	1.38 (1.04-1.84)	0.027	1.58 (1.17-2.13)	**0.003**
	Night	48/40.7	2.01 (1.32-3.04)	**0.001**	2.32 (1.51-3.57)	**<0.00**
Porters available	Yes	374/26.0	1			
	No	273/31.3	1.30 (1.08-1.56)	**0.006**		
High work load	No	241/28.4	1			
	Yes	406/27.8	0.97 (0.81-1.18)	0.786		
Additional test	BG, XM	52/22.6	1		1	
	BG	213/26.3	1.22 (0.86-1.72)	0.262	1.15 (0.81-1.64)	0.444
	CBC only	382/30.1	1.48 (1.06-2.06)	**0.021**	1.57 (1.12-2.21)	**0.009**
Daily condition or event**	No event	483/26.8	1			
	Equipment fail	18/36.0	1.54 (0.86-2.77)	0.150		
	Computer	45/34.6	1.45 (0.99-2.11)	0.054		
	Reagent	33/36.7	1.58 (1.02-2.46)	**0.041**		
	Service	13/31.7	1.27 (0.65-2.47)	0.482		
	Tech. Short	55/28.4	1.08 (0.78-1.50)	0.638		

NB: * lower than 50 test, BG= blood group, XM=Compatibility test, CBC=Complete Blood Count, ** CBC Analyzer not working, Computer connected to CBC failed, Reagent short, technologist short. COR= Crud Odds Ratio, AOR= Adjusted Odds Ratio, CI Confidence interval, Additional test= BG and/or XM ordered along CBC test.

The determined TAT for chemistry test are longer and affected by both; days of week and shifts of a day. Samples received during Saturdays are relatively small (10.2%) compared to other weekdays and longer TAT [338.8 ± 365.0; 210 (148-301)], 949 min 90th percentile completion time were also recorded in these days. Based on shifts of the day, 30% of chemistry samples are received in mid-days (11:00-14:00 hours) and 90% of tests are completed in 301 minutes which is the shortest completion TAT compared to specimens received in other shifts. Overall, significant ($P<0.05$) average chemistry test TAT variations were observed between weekdays as well as shifts of the days [table 2].

In this assessment period, AaBET laboratory clinical chemistry work unit's 548 (30.1%) of the result were not ready on predefined time (240 min or 4hr) due to various possible factors. Among the weekdays, the highest proportions (43%) of delayed test result were observed on Saturdays and significantly ($p = 0.004$) contribute for chemistry TAT delay. Days of shift differences also showed significant ($p < 0.001$) association to chemistry result delay and test samples received during afternoons and evenings were approximately three times more likely to have delayed TAT than those samples received in the morning shifts, (COR = 2.88, $P <0.001$) and (COR = 3.64, $P <0.001$), respectively. Similarly, chemistry testes analyzed on quality control and equipment failed days were two and three times more likely to have a delayed TAT than tests done on days having normal conditions, (COR = 2.05, $P = 0.006$) and (COR = 3.03, $P <0.001$), respectively. However, unavailability of porter to transport test sample significantly ($P = 0.020$) associate with chemistry test result delay, difference in daily work load and additional (serological) tests did not show significant association to delayed chemistry TAT. Overall, mid-days, afternoons, nights shift, daily work load variation, quality control and equipment problems were identified as independent predictors for presence of chemistry tests result delays [table 4].

Table4 Association of independent characteristics with magnitude of TAT delay among chemistry test performed in AaBET hospital, Addis Ababa 2022.

Characteristics		TAT Delay N/%	Bivariate regression		Multivariable regression	
			COR (95 C.I.)	P-value	AOR (95 C.I.)	P-value
Days of week	Monday	85/29.8	1			
	Tuesday	73/25.0	0.78 (0.54-1.13)	0.194		
	Wednesday	87/29.3	0.97 (0.68-1.39)	0.888		
	Thursday	73/27.4	0.89 (0.61-1.29)	0.537		
	Friday	88/30.9	1.05 (0.74-1.50)	0.785		
	Saturday	80/43.0	1.78 (1.21- 2.61)	**0.004**		
	Sunday	62/29.2	0.97 (0.66-1.44)	0.889		
Days of shifts	Morning	92/20.7	1		1	
	Mid-Day	146/26.4	1.38 (1.02-1.85)	**0.035**	1.38(1.02-1.87)	**0.035**
	Afternoons	185/43.0	2.88 (2.15-3.91)	**<0.001**	2.94 (2.17-3.98)	**<0.001**
	Evening	79/26.5	1.38 (0.98-1.95)	0.065	1.32 (0.93-1.87)	0.122
	Night	46/47.4	3.46 (2.19-5.48)	**<0.001**	3.50 (2.20-5.57)	**<0.001**
Porters available	Yes	317/28.1	1			
	No	231/33.2	1.27 (1.04-1.56)	**0.020**		
High work load	Yes	354/28.6	1			
	No	194/33.0	1.23 (1.00-1.52)	0.055	1.35 (1.07-1.69)	**0.010**
Additional test	Yes	18/28.6	1			
	No	530/30.1	1.08(0.62-1.88)	0.793		
Daily condition or event**	Usual event	362/28.7	1		1	
	QC fail	28/45.2	2.05 (1.22-3.42)	**0.006**	2.22 (1.31-3.76)	**0.003**
	Equipment fail	39/54.9	3.03 (1.87-4.91)	**<0.001**	3.27 (1.98-5.39)	**<0.001**
	PM Weekly	80/29.2	1.02 (0.77-1.37)	0.871	1.07 (0.80-1.44)	0.659
	PM Monthly	13/33.3	1.24 (0.63-2.44)	0.531	0.81 (0.40-1.64)	0.550
	Tech. short	26/22.4	0.72 (0.46-1.13)	0.151	0.71(0.45-1.13)	0.152

NB: * lower than 30 test, ** Equipment not working, Quality control failed, technologist short. PM= preventive maintenance, COR= Crud Odds Ratio, AOR= Adjusted Odds Ratio, CI Confidence interval, Additional test= Serology test order along chemistry test.

7. Discussion

Quality can be defined as degree to which a set of inherent characteristics fulfills requirements (ISO 9000). The goal or inherent characteristics of an efficient and effective laboratory is to provide consistently accurate results in a "timely manner" with the most judicious use of resources [32]. Measurement of the turnaround time such us, compliance with internal TAT standards for ED stat examination, compliance with TAT standards promulgated by accrediting agency and clinical professional societies is one of the quality indicator topics provided by CLSI that should be used to monitor whether or not the laboratory service is meeting its quality intentions [33]. Also, tracking the time intervals for laboratory TATs makes it possible to identify weak points and improve the quality of care [34]. This study was designed to determine the reception to releasing TATs for CBC and chemistry testes ordered in AaBET hospital and assess the possible factors that have contributed for result delay.

Results of this study revealed that the 90% of CBC and clinical chemistry tests completion time were 105 and 457 minutes, respectively. These results are longer than the available international or AaBET laboratory suggestions (bench marks) [21, 22]. Findings of Mahdaviazad Het al., who calculated the TATs of 1328 CBC and chemistry tests ordered by the ED of a general tertiary care teaching hospital in Iran, revealed that the90%completion time of 3.5 hours which is also lower result [18].This variation in TAT may be due to limited number of equipment and technology difference since AaBET lab has 1 hematology and 1 chemistry functional automated analyzers the other; CBC=3, chemistry=1 and Electrolyte=1 analyzers are idle during this study period. However, Mahdaviazad's laboratory has more than 8(4 to each) automated analyzers [18]. In 2017 Archetti C. et al also found that, the introduction of automation in Spedali Civili hospital laboratory, Italy led to quite remarkably improved for urgent and routine exams TAT [35].

Average TAT in our study for CBC was 53.9±53.4 with median (IQR); 37 (22-66) minutes and 257.4 ± 287.9 with 173 (110-267) minutes were for chemistry tests. This finding was lower than observed form Iran, revealed that hemoglobin had a median of 170 min (113–269.5) and serum potassium had a median of 225 min (167.25–324.5) [24]. These differences might be due to TAT definition differences, which is TAT was defined from test ordering to result delivering in

previous study verses from specimen reception to result releasing were used in our study [24]. A study from Kenya documented, the post analytic period contributed the most delay resulting in more than 20 hours of therapeutic TAT [20]. From Nepal, also nearly half of the total affected TAT was observed due to problem in cash unit [17]. However, similar study (from ordering to result delivering) in Gondar University hospital recorded a 262.28 minutes average TAT for chemistry tests, which is comparable to this study result [16].

The comparison of shifts of the day and days of the week showed the longest mean TAT for CBC was during night shift (00:00 – 06:59), for chemistry afternoon (14:00- 17:59) followed in night shifts and chemistry test samples received on Saturdays. Although the one-way ANOVA analysis of these results were statistically significant ($P < 0.05$), means of CBC TAT between days of the week showed non-significant variation. Different finding from previous study by Mahdaviazad Het al., who observed that the shortest mean TAT during night period which have also a lower work load [18]. However in this study the lower sample flow periods has the longest TAT. These may be explained by the batch analysis more common for chemistry test, and analyzers shutdown periods are in the night shift or between 03:00 and 06:00. Additional factors that may have contributed to the longer TATs during these periods are, technologists assigned to multiple tasks, and unavailability of sample porters. These observations supported by Jalil M. et al, and BlickE.'s findings, which showed unavailability of dedicated personnel (technology) for specimen transport, and the legacy batch approach to specimen handling and analysis, adds to the complexity of lab processes as well as longer TAT [22, 24].

Nearly 28.0% of CBC and 30.1% of chemistry tests results were not achieved the TAT goals stated in AaBET laboratory quality policy, which is lower than finding from the Clinical Biochemistry Laboratory of Dhulikhel Hospital, Nepal that is 38.7% of EM and ICU samples have prolonged TAT [17]. The shortest TAT or only 2.0% of test result time delay recorded from South Korea, this means 98.0% of the specimens were reported within 60 min. [14]. These difference attributed to, factors affecting TAT in clinical laboratories may vary from institute to institute depending upon institutional infrastructure, their own setup, policy, system and attributes of employees working in different departments of the hospital [17].

In this study, evening (18:00-0.00), night (00:01- 06:59) working shifts and requesting CBC without BG and/or compatibility test were identified as independent predictors of delays in CBC

test results. On the other hand, afternoon (14:00-17:59) shifts, night (00:01- 06:59) shifts, less work load days, quality control problem and equipment fail were found significantly associated to delayed TAT in chemistry testes. Overall CBC (25.5% and 28.2%) and chemistry (20.7% and 26.4%) of test specimens received in the (morning and mid-day, respectively) showed relatively lower proportion of delay as compared to the other shifts. These was inconsistent to the study from India, which most of the delay in TAT of CBC and chemistry tests occurred in the lunch break (59.22%) and early morning (29.33%)due to less staff members and increase in workload during these time [35]. Even though, in AaBET lab higher workload was observed during these shifts, less staff numbers are observed in evening and night shifts. The legacy batch approach to specimen handling and analysis that is, more sample flow leads to increase the sample transport and batch analysis frequency [22].

Since our study area is a trauma hospital, compatibility testing are more frequently request received by the laboratory for instance from 275 to 325 cross-match tests are performed per month thus, CBC test specimens submitted along compatibility test are considered top urgent sample which showed also a lower frequency of delay and this could be the reason for CBC test requested without BG and/or compatibility test significantly associated to delay in CBC TAT. According to Hawkins R article review, TAT to be affected by a variety of factors the first are uncontrollable institutional factors, such as institution type [10].

Another important reason for delay in our laboratory related to equipment problems. Almost all these problems arise from poor function of water purification part of the chemistry analyzer due to unavailability of spare part in local market and shortage of technicians to conduct service maintenance. Chemistry test performed in days that have encountered internal quality control analysis and these equipment problems showed significant delay as compared to test analyzed in normal conditions. Similarly, University Hospital of Kinshasa does not comply with either international standards or the suggestions (requirements) of attending physicians who are the laboratory's primary clients because of many reasons such as root causes related to Manpower (non-retrained staff), and Machine (insufficient number, defective, not maintained, and low-power machine) [37].Machine breakdown followed by problems in machine maintenance and overlook of technical staff was also found to be the most common reason for delay in Aga Khan University Hospital, Karachi [38].

8. Strength and Limitation of the study

8.1 Strength of the study

AaBET Hospital is the first dedicated Emergency and Trauma hospital in Ethiopia. Therefore this study is the first to assess CBC and chemistry tests' TAT in hospital that dedicated particularly for Emergency and Trauma care in Ethiopia. Relatively a higher number of tests' TAT are examined through 24 hours of day with in four month study period, so these enables the time data provided to be more representative. Through this study, we identify various possible factors to delay which will help to implement mechanisms to mitigate long TAT.

8.2 Limitation of study

This study has some limitations which shall be declared.

- Only specimen reception to result verification time intervals were assessed
- External, internal staff related factors and physician expectations are not addressed

9. Conclusion and Recommendation

9.1 Conclusion

In AaBET hospital laboratory 90% completion TAT for CBC and chemistry tests were 105 and 457 min respectively. These determined TATs are longer than and also doesn't comply with the available international or AaBET lab suggestions (bench marks) and only 72.0% CBC and 69.9% chemistry tests were completed within these bench marks (pre-determined) TATs. Despite the extensive documentation of delay in specimen received during, working days of week, morning shift, launch shifts, and high workload time, this study found that non-significant delay were observed during these conditions. Sunday working days, Afternoon, Evening, and Night shifts, no sample porter and machine related problems were identified as significant factors for delayed TATs. Furthermore, although this study found that the mean [CBC= 53.9 (53.4) and Chemistry= 257.4 (287.9)] TAT in this trauma hospital is in consistent with the available bench marks, very large dispersion of TAT were observed between each testes. Therefore, the legacy batch approach to specimen handling and analysis with machine unavailability for backup use leads to these root causes of the delay.

9.2 Recommendations

Based on our findings, we recommend the following to improve this slow and unacceptable laboratory turnaround in the emergency hospital.

- The laboratory manager should assign appropriate numbers of staff at each work areas during all working shifts and efficient uses of the available specimen porters is expected from all lab professionals.
- The laboratory manager should revise and reschedule equipment (analyzers) preventive maintenance and internal quality control analysis time schedules.
- The laboratory manager together with the hospital higher officials should find a solution to analyzers that are out of order, which could be used as a backup machine.
- Along manpower and information technology improvement, related stake holders should look forward to apply automated sample transfer system in emergency hospitals.

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11 Annex

Annex I. Participant information sheet(English version)

Principal Investigator: Betelehem Adibib, Addis Ababa University, College of Health Sciences, Department of Medical Laboratory Sciences, Addis Ababa, Ethiopia.

Title of the research project: Assessment of Laboratory Turnaround Time and associated factors for Complete Blood Count and Clinical Chemistry Testes in Emergency and Trauma Hospitals, Addis Ababa, Ethiopia.

Purpose: the purpose of this study is to assess laboratory turnaround time and associated factors for complete blood count and clinical chemistry tests at Addis Ababa Burn, Emergency and Trauma hospital.

Procedures: After obtaining permission from respective hospital administration body AaBET laboratory daily routine work flow will be observed and recorded by principal investigator or assigned data collectors. You all laboratory staff are invited to take part in the study and after taking your consent your some information and your daily activity will be noted and recorded as needed.

Risks associated with the study: There is no risk and serious invasive procedure at the beginning as well as at the end of the study.

Benefits of the study: There will be no financial or other direct benefit to you.

Confidentiality of your information: The results of the findings will be keptconfidential and could only be accessed by the researcher. There will be no personal name mentioned instead a unique code will be used to label your information which are required for the study purpose.

Contact information: If you have any questions about this study you can contact with the following address. BetelehemAdbib; Principal Investigator

Email: -betidebe4@gmail.com **Telephone:-**+251911362683

I understand the objective of this study and agreed to participate in the study.

Signature ______________________ Date __________________________

Annex II. Sample and test request information collection form

No	Question and/characteristics	Possible response/observation	Skip
01	For patients who had at least 1 of 2 laboratory tests (CBC count, chemistry panel [RFT, Electrolyte])	Sample id from barcode	
1.2	Sample acceptance status	01] Accepted☐ 02] Unaccepted ☐	02 stop
02	Collection/reception time HH:MM:SS	_ _:_ _;_ _	
03	Collection/reception date	DD/MM _ _/_ _ 04] Thursday ☐ 01] Monday ☐ 05] Friday ☐ 02] Tuesday ☐ 06] Saturday ☐ 03] Wednesday☐ 07] Sunday ☐	
04	Collection/reception shift	01] Morning 07:00 – 11:00 ☐ 02] Noon time 11:01 – 14:00 ☐ 03] After noon 14:01 – 17:59 ☐ 04] Evening 18:00 – 23:59 ☐ 05] Night 00:00 – 06:59AM ☐	
05	Sample collection status	01] collected at point of care area☐ 02] collected by laboratory staff☐	
06	Sample container type	01] EDTA- Tube☐ 02] SS-Tube☐ 03] Both ☐	
07	Test request information for EDTA-Tube specimen	01] CBC 01] Yes ☐ 02] No ☐ 02] B.G. & Rh 01] Yes ☐ 02] No ☐ 03] Compatibility test 01] Yes ☐ 02] No ☐	
08	Test result urgency/CBC	01] Routine☐ 02] Urgent ☐	
09	Test request information for SS-Tube specimen	02] RFT 01] Yes ☐ 02] No ☐ 02] Electrolyte /Na, K, Cl/01] Yes ☐ 02] No ☐ 03] Electrolyte &Ca, Mg, Phou01] Yes ☐ 02] No ☐ 04] Other Chemistry 01] Yes ☐ 02] No ☐	

		05] Serology 01] Yes □ 02] No □	
10	Test result urgency/Chemistry	01] Routine □ 02] Urgent □	
11	If urgent, specify urgently needed	01] RFT □ 02] Electrolyte □ 03] All □	
12	Test request received from/ED	01] Yellow and Green side □ 02] Orange side □ 03] Red side□	
13	Test request received from/critical wards	01] ICU □ 02] Orthopedics □ 03] Neurosurgery □ 04] Burn/Plastic □ 05] Surgery room □ 06] Recovery room □	
14	Test request received from follow up	01] OPD/Otho□ 02] OPD/Neuro□	
15	Time a specimen is received at the central lab specimen receiving and processing area HH:MM:SS	[__ __:__ __:__ __]	Urgent skip
16	Time a specimen is received at the hematology testing section HH:MM:SS	[__ __:__ __:__ __]	
17	Time a specimen/s is/are loaded on to hematology analyzer HH:MM:SS	[__ __:__ __:__ __]	
18	Time a CBC result printed from the analyzer HH:MM:SS	[__ __:__ __:__ __]	
19	Time a specimen is received at the chemistry testing section HH:MM:SS	[__ __:__ __:__ __]	
20	Time a specimen/s is/are loaded on to chemistry analyzer HH:MM:SS	[__ __:__ __:__ __]	
21	Time a chemistry test result printed from the analyzer HH:MM:SS	[__ __:__ __:__ __]	

22	Date and time CBC result verified and released	Date __/__ [__ __:__ __:__ __]	
23	Date and time chemistry result verified and released	Date __/__ [__ __:__ __:__ __]	
24	Chemistry test performed by:		
25	CBC performed by:		
26	Critical test result CBC	01] Yes □ 02] No □	
27	Critical test result chemistry	01] Yes □ 02] No □	
28	Total number test performed		

29**Comment i.e**. if testing process are interrupted due to any of the following reasons

- Reagent short □
- Sample clog □
- Power failure □
- Water shortage □
- LIS failure □

Annex III Daily work area evaluation or observational checklist

No	Resource for the daily activities or work	
01	All staff are available at all work section on time based on daily duty roaster	01] Yes □ 02] No □
02	Equipment preparation for daily work is performed and any problem identified are resolved properly	01] Yes □ 02] No □
03	Reagents and consumables are ready and sufficient for the day work load	01] Yes □ 02] No □
05	Calibration and internal QC performed and no problem encountered	01] Yes □ 02] No □
06	LIS programs are working properly	01] Yes □ 02] No □
	Tata collection date	

Declaration

I, the undersigned, declare that this M.Sc. thesis is my original work, has not been presented for a degree in this or any other university and that all sources of materials used for the thesis have been duly acknowledged.

M.Sc. Candidate; Betelhem Adbibi (BSc)

Signature:___________________

Date of submission:___________________

This proposal has been submitted with our approval as advisors.

Advisor: Fatuma Hassen (MSc, MPH,PhD candidate)

Signature: _____________________

Date: _____________________

Place: Addis Ababa, Ethiopia.

Advisor: Semira Rahmeto (MSc)

Signature: _____________________

Date: _____________________

Place: Addis Ababa, Ethiopia.