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EVALUATION OF LABORATORY DESIGN AND ERGONOMICS WORKSTATION IN CLINICAL LABORATORY IN ADDIS ABABA, ETHIOPIA

BY

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A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY IN PARTIAL FULFILMENTS OF THE REQUIREMENTS FOR THE DEGREE OF MASTERS IN CLINICAL LABORATORY SCIENCES

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Evaluation of Laboratory Design and Ergonomics Workstation in Clinical Laboratory in Addis Ababa, Ethiopia

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Declaration

I, the undersigned, declare that this is my original work, sole author of this thesis, and has never been presented in this or any other University and that all the source materials used for this thesis have been duly acknowledged.

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Dedication

I dedicate this thesis to my beloved wife, Betselot Woreku; for the understanding and encouragement she provided during all these years of study and her endless love has made it possible to accomplish what I have. And of course, I can't forget the centre of attention, our two sons who I hope understands why I can't play the entire day every day!

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Acronym

AOD	Adjusted Odds Ratio
ART	Antiretroviral therapy
BSC	Biological Safety Cabinets
CDC	Centers for Disease Control and Prevention
CL	Confidence Level
CLSI	Clinical and Laboratory Standard Institute
CTD	Cumulative Trauma Disorder
CTS	Carpal Tunnel Syndrome
e-al	and others
FMOH	Federal Ministry of Health
ID	Identification
IRB	Institutional Review Board
Lab	Laboratory
LSA	Lean System Approach
MSD	Musculoskeletal Syndrome Disorder
NMQ	Nordic Musculoskeletal Disorder
NSM	Net Square meter
TNS	Total Net Assignable Square Meter
OD	Odds Ratio
OPD	Outpatient Department
OSHA	Occupational Health and Safety Agency
P	Probability obtaining a test statistic
PT	Protrobine Time
PTT	Partial Protrobine Time
RMI	Repetitive Motion Injury
RSI	Repetitive Strain Injuries
SD	Standard Deviation
SOP	Standard Operating Procedures
TNS	Total Net Square
UPS	Uninterrupted Power Supply

WHO	World Health Organization
WRMSD	Work-Related Musculoskeletal Disorder
WS	Workstation

Abstract

***Background**: Since advancement of science and technology in the area of laboratory medicine in 21st century the design of laboratory should be organized into high flexibility zones and need an open plan to support the dynamic nature lab testing by manual or semi-automated or fully automated. The most difficult issue in design of laboratory is allocation and organization of space. Although well design laboratory is in place, it will be compromised if the ergonomics workstation and workflow of laboratory are not designed well. In Ethiopia there is no baseline information on laboratory design, ergonomics workstation, and workflow sited on literature.*

***Objective:** To evaluate the ergonomic workstation, workflow and laboratory design in clinical laboratory in Addis Ababa, Ethiopia.*

***Method:** A cross-sectional study design was used. Quantitative method and direct observation were conducted.*

***Result**: **Ergonomics**: Work-related musculoskeletal complaint was strongly associated with poor ergonomic workstation. A one year increased in work experience and age of employee, the odds in favor of compliant were estimated to be increased by a multiplicative factor of 1.374 and 0.921 respectively. A total of 117 ergonomics workstation was evaluated. The overall workstations mean score was 1.95 and 66.6% of workstation found a mean score of two and below which indicate poor ergonomic conditions.*

***Workflow**: A total of 28 specimen collection workflow and 26 chemistry laboratory workflow were identified. A total of 8 non-valued added steps were recognized from the existed chemistry laboratory workflow. The average time of samples waiting at reception prior to delivery to respective laboratories were decreased as more samples collected within short time interval. The average cycle times of 489 blood sample drawing process were 3.58 minutes and 76.5% (374) of blood samples were drawn with an average cycle time of 1.0 to 5.0 minutes. A total of 1231.31 minutes were identified as non-value added (waste) time from existed workflow of chemistry blood samples testing process and seven non-valued added process steps were recognized. Clinical chemistry laboratory process cycle efficiency was 56.6%. **Laboratory design**: The adjoining and adjacent matrix principles were not documented in assessed laboratories. The laboratory design didn`t show the direction of evacuation plan during emergency situation and fire extinguisher were not strategically*

placed and free of obstruction. Black lion hospital laboratories did not have any mechanical ventilation system. Laboratory and non-laboratory activities were not separated.

***Conclusion and recommendation**: Hospital laboratories should aware of ergonomics principle and application and whenever new laboratory equipment purchase order in place it would have been much better to consider the three factors: quality, cost and ergonomic specification of product. Laboratory employees shall modify or reconfigure or reposition the workstation or equipment to fit the work to yourself not you to fit to work and by doing this possible to prevent associated musculoskeletal disorders. Concerning the workflow, laboratories should identified non-value added process or steps or activities and by eliminating those wastes and implementing a powerful business improvement tools like lean method possible to maximized customer needs. Laboratories must assess their workflow periodically to identify wasteful practices and focused only value-added activity to increase the process cycle efficiency and productivity.*

Whenever laboratory construction or renovation at the stage and prior to design, identifying the size and nature of laboratory test being performed, laboratory workflow, number and size of laboratory equipments needed, type and number of ergonomics casework and countertops, number of sinks available, aisles between workstation and equipments, position of utility cords, plumbing fixtures, location of safety station, emergency evacuation plan, number and size of doors and windows, access control areas, and the like should be identified and calculated in detail early in planning and programming phases of laboratory design.

Furthermore, Laboratory proximity programming and functional relationship between laboratories and reception should be determined early in design process and laboratory module unit space size determination and open plan laboratory together with lean laboratory design should be consider in design process. Finally, laboratory manager, engineer, architecture, hospital administrator, other relevant individual must be part of laboratory design construction and renovation team.

1 Introduction

Laboratory process designs are broad overall plans used to develop and design a process or way of completing work or doing a task. Once the process designs are developed workflow can be analyzed. Workflow is the pathway in which work follows from the beginning to the end of task. Process designs can be complex or simple depending on the size of the task or the amount of work that needs to be done (1).

The implications of laboratory design can be explained as the clinical lab should be organized into three flexibility zones (highly flexible, semi-flexible and least flexible) that correspond to technological requirements since the equipment is central to the function of the lab; a lab needs an open plan to re-evaluate and reconfigure furnishings, to support the dynamic, sequential movement of the specimen, and to remain operational as new technologies are added; plug-and-play utility systems (such as overhead service carriers) should be included, particularly in the highly automated areas, Modular furniture, adjustable height tables, and movable furniture are recommended so as workstations can be removed or reconfigured as technological processes change (2).

The laboratory design process encompasses many elements like space, case-work or workstation, furniture, storage, ventilation, lighting, water, wall, floor, equipment, etc. (3). Among the most difficult issues in design of laboratory is allocation and organization of space. Now a day's most laboratory shall pass through accreditation process to be competent in the market and then space issue is major area since lack of adequate space may compromised the quality of work performed by the laboratory.

Adequacy of space can be explained as putting something into space and measure physically when limits the space itself. However, usually when the laboratory builds initially the space may be enough but through time more and more objects are putting together into limited space and this leads to dysfunction of the work (3).

The laboratory design and layout define traffic patterns, workflow and the functionality of a laboratory. Laboratory safety is also directly affected by decisions made about the quantity, quality, type and organization of laboratory casework and furnishings. A laboratory should have enough well-configured casework, both floor and overhead if necessary so that the functionality and safety of the laboratory is not compromised. Too much casework for the square footage of laboratory space available is a more common problem than too little casework (3).

Ergonomics is the field of study that seeks to fit the job to the person, rather than the person to the job. This is achieved through the evaluation and design of workplaces, environments, job tasks, equipment, and processes in relationship to human capabilities and interactions in the workplace. Anytime there are changes in the workplace (new employee, new chair, new desk), new ergonomic solutions are required. It is important that all furniture (chairs, desks) and other accessories are adjustable in order to meet individual worker's needs (4).

Laboratory work does not have to be a pain in the neck, shoulder, back, arms, legs, eye, or other. There are many simple ways for laboratories to prevent or remediate repetitive strain injuries (RSIs) that are associated with their work. Poor posture is among the most common problems, especially for technologist and pathologist who spend hours at microscope (5).

Lean is derived from methodologies developed in the Japanese automobile industry. It is a systematic approach to improving the reliability of processes through the identification and elimination of operational barriers and sources of variability within a process or system (6).

Leans Systems Approach (LSA) improves process by identifying each step, removing non-value added steps, and eliminating waste. The benefits of applying such principles will make a more efficient and timely delivery of products (7).

2 Statement of the problems

Today's clinical laboratory is one of a hospital`s largest departments and produces vital information for effective healthcare delivery. Clinicians depend daily on the clinical laboratory data for patient care. The modern clinical laboratory is a sophisticated network of people, machines, and processes tightly coupled with the clinicians. Laboratory tasks often require intense eye-to-hand coordination, frequent use of the arms for precision work, manual materials handling, and high demands on visual concentration so that in the process of laboratory design, ergonomics needs to be an integral factor (2).

It has been recognized that laboratory design process should not only left for engineer and architects who have active roles in building construction. Laboratory manager or laboratory professional shall participate in the design of laboratory since the inability to obtain informed input at critical points may result the laboratory staff finds less than satisfactory in both form and function laboratory (1).

Workstations should be tailored to match the human anthropometry (human measurements) to minimize extreme postures, improve task efficiency and provide a safe work environment. The physical design and layout of a laboratory can significantly affect performance, health, safety, product quality, and production efficiency. Today, technology has advanced to include automated processes for centrifugation, chemical and biological assays, and processing. These advancements, however, have exposed people working inside high-tech labs to new hazards: cumulative trauma disorders such as tendonitis, carpal tunnel syndrome, and back disorders which enforce the laboratory to give attention to ergonomic issues and preventing the development of work-related musculoskeletal disorders, as well creating a more safe and productive workplace (4).

Furthermore, a well design laboratory with good ergonomics workstation and efficient workflow are paramount in producing timely, accurate and reliable result, and safety of laboratory personnel’s (8). Therefore, when the laboratory design is in place, ergonomics workstation and workflow should be incorporate at initial phase

Working in laboratories where the laboratory design is in question and knowledge of ergonomics where limited, it will have great impact on laboratory personnel productivity and safety, life-span of lab equipment, quality of service, customers satisfaction, efficiency of workflow, working environment (3). Thus, the ergonomics workstation and workflow are highly interrelated each other and study them together with laboratory design. Therefore, identifying the major gaps on laboratory design, ergonomics and workflow will helps us to find opportunities for improvement and possible to propose better laboratory design.

Therefore, generating a baseline data and information by studying the current situation and proposing new laboratory design, ergonomics workstation and workflow may be very useful for those working on laboratory design infrastructure and ergonomics in both governmental and non-governmental organization particularly engineers, arthritics and laboratory manager.

3 Literature Review

3.1 Ergonomics workstation and work-related musculoskeletal discords

A study conducted in Oman on office ergonomics, major ergonomic deficiencies were found in physical design and layout of the workstations, employee postures, work practices, and training. Forty-five percent of the employees used nonadjustable chairs, 48% of computers faced windows, 90% of the employees used computers more than 4 hrs/day, 45% of the employees adopted bent and unsupported back postures, and 20% used office tables for computers. Major problems reported were eyestrain (58%); shoulder pain (45%), back pain (43%), arm pain (35%), wrist pain (30%), and neck pain (30%). These results indicated serious ergonomic deficiencies in office computer workstation design, layout, and usage (11).

Study done in U.S. Department of defense there were 600,000 injuries per year involve lost work days due to musculoskeletal disorder and ergonomics related injuries account for $ 20 million in worker`s compensation costs each year. An ergonomics work environment can increase productivity on average by 11%. The average federal government cost (medical and worker`s compensation costs) for a carpal tunnel syndrome case is $ 8,799 and 42% of carpal tunnel cases result in more than 30 days ways from work (15).

In Washington state work-related musculoskeletal disorders are the leading type of occupational injury and incur the greatest costs to industry and the worker`s compensation system. Musculoskeletal disorders affect soft tissues, such as muscles, tendons, ligaments, nerves and blood vessels. From 1992 through 2000, workers compensation claims for these injuries totaled $ 2.9 billion and accounted for 27% of all workers' compensation claims in Washington State (16).

Study conducted in Alberta shown that grip forces used with many types of lab equipment involves high hand force, such as pipetting and operating microtome hand wheel. Many of these forces are a result of using pinch grasp for squeezing or specific digits such as the thumb during pipette work. High hand forces or high repetition increase the rate of fatigue of the muscle leading to shortening of the muscle and potentially micro-tears in the tendon (17).

Aches and pains, tingling, numbness, or burning sensations in the hands and forearms, perhaps interrupting sleep at night, can be symptoms of cumulative trauma disorder (CTD), also known as repetitive motion injury (RMI). This disorder is one of the fastest growing occupational illnesses (18).

Documentation of repetitive motion injuries in the laboratory has only recently been published. Many histology professionals have carpal tunnel syndrome (19). It is estimated that 14.8% of histology professionals have chronic pain related to repetitive motion. Statistically significant risk factors for pain or diagnosis of repetitive motion injuries for this group are microtomy, cover slipping, and computer data entry (18).

Laboratory researchers are at risk for repetitive motion injuries during routine laboratory procedures such as pipetting, working at microscopes, operating microtomes, using cell counters and video display terminals. Repetitive motion injuries develop over time and occur when muscles and joints are stressed, tendons are inflamed, and nerves are pinched and the flow of blood is restricted. Standing and working in awkward positions in laboratory hoods/biological safety cabinets can also present ergonomic problems (20).

3.2 Laboratory workflow

A reviewed done by Christopher indicated that laboratories can adopt lean principles (after careful work flow and work load evaluation) that can decrease unnecessary steps. Automation should be considered to replace manual tasks that require standardization, or that could cause musculoskeletal disorders. Work areas should be evaluated so that commonly used items are within a comfortable reach. Ergonomic chairs and adjustable countertops and workstation should also be available (5).

Study done by Stankovic the impact of applying lean management principles to the urine specimen collection and handling process shown that Non-value-added or error-prone steps are either removed or controlled in the revised process, resulting in a more efficient, timely, and standardized process. Specifically, by changing the method of urine specimen collection, 11 steps were removed from the process. All three of the error-prone steps were eliminated, two of them in the pre-analytical phase, including the open transfer of specimens into tubes from cups and relabeling of specimens. Five non-value-added steps were eliminated, three from the pre-analytical phase, which increased the efficiency and reduced the waste of the laboratory staff and materials. Overall, the eliminated steps represented 64% of all steps in the process (12).

3.3 Laboratory design

A study conducted by university of Minnesota, almost 90% of labs modified workstations, 66% added furniture, 62% consolidated furniture, and 44% replaced worktops. An average of all respondents reveals that more than 75% of lab furniture in the core lab is fixed or built-in, limiting reconfiguration of the lab. Lab staff reported a trend toward movable or modular furniture (13).

The majority (70%) of labs surveyed replaced, upgraded, relocated, or expanded one or more infrastructure systems in a five-year period, and 43% made changes to multiple units or the entire system. Renovating and relocating lab functions were the most common space plan changes reported. Furthermore, 74% of the labs renovated their interior layout at least once, involving between 16% and 36% of the total lab space. In addition, 68% of labs relocated functions and/or departments at least one time during study period, involving 11% to 27% of the total lab space. Moreover, 90% of labs relocated multiple pieces of equipment at least once, and 97% purchased or leased new equipment at least once in indicated years (13).

Case study done in Georgia public health laboratory indicated that the light-filled design enhances productivity by increasing the staff`s ability to work comfortably at the bench for longer periods of time. Space needs are determined by the volume of incoming samples; staff can either downsize or expand a module by simply vacating a bench or assuming occupancy of an adjacent bench (14).

The primary objective in laboratory design is to provide a safe environment for laboratory personnel to conduct their work and allow the maximum flexibility for safe laboratory diagnostic service and produce high quality lab tests. No matter how well designed a laboratory is, improper usage of its facilities will always defect the engineered safety feature. Because the handling and storage of hazardous materials inherently carries a higher risk of exposure and injury, it is important to segregate laboratory and non-laboratory activities (8).

Laboratory space should be physically separate from personal desk space, meeting space and eating areas. Workers should not have to go through a laboratory space where hazardous materials are used in order to exit from non-laboratory areas. Consider making visible separation between lab and non-lab space, for instance with different flooring. Laboratories should have an abundant umber of electrical supply outlets to eliminate the need for extension cords and multi-plug adapters. Ground fault circuit interrupters should be installed near sinks and wet areas (9).

Maximizing flexibility has always been a key concern in designing or renovating a laboratory building. Flexibility can mean several things, including the ability to expand easily, to readily accommodate reconfigurations and other changes, and to permit a variety of uses. In the past equipment was often squeezed into an existing lab setup; today`s labs must be designed to accept the needed equipment easily. There are several types of movable casework to consider. Mobile carts make excellent equipment storage units (10).

4 Objectives

4.1 General Objective

- To evaluate ergonomic workstation in relation to work-related musculoskeletal disorder, workflow and laboratory design in hospital laboratory in Addis Ababa, Ethiopia.

4.2 Specific Objective

- To evaluate laboratory ergonomic workstation in relation to work-related musculoskeletal disorder in nine hospital laboratories in Addis Ababa, Ethiopia.
- To describe the existed laboratory workflow and propose a new workflow in Black Lion Specialized Teaching Hospital Laboratory.
- To describe the existed laboratory design setup and propose new lab design in Black Lion Specialized Teaching Hospital Laboratory.

5 Methods and Materials

5.1 Study Area

Addis Ababa is the capital city of Ethiopia and the social, political, and economic centre of the country. Addis Ababa had an estimated population of 3.14 million and is divided into 10 sub-cities. The study conducted on nine public hospitals (four were federal and five were under Addis Ababa Region).

5.2 Study Design

A cross-sectional study design was conducted to evaluate the laboratory design, workflow and ergonomic workstation in relation to work-related musculoskeletal disorder at selected hospitals in Addis Ababa. Quantitative methods and direct observation using checklist were utilized. Laboratory design and workflow assessment was conducted in Black Lion Specialized Teaching Hospital Laboratory. However, evaluation of ergonomic workstation in relation to work-related musculoskeletal disorder was conducted in nine hospitals Addis Ababa, Ethiopia from November 2011 to February 2011.

5.3 Source population

All government hospital laboratory personnel in Addis Ababa were source of population.

5.3.1 Study Population

Government hospital laboratories and their workers were the study population. Accordingly, two study populations were included:

A. **Ergonomic workstation and work-related musculoskeletal disorder:**
   Laboratory personnel who had been working in nine hospital laboratories for more than a year and study their ergonomics workstation
B. **Laboratory workflow and design assessment**
   Black Lion Specialized Teaching Hospital was selected.

5.4 Sampling Method

A. **Ergonomic workstation and work-related musculoskeletal disorder**

The study used simple random sampling techniques by determining a minimum sample size.

5.4.1 Sample Size

- The sample size was determined using a minimum sample size formula. Since there was not any baseline data in Ethiopia on ergonomics work-related disorders the study was conducted a pilot sample of 30 laboratory personnel who had been working in the laboratory more than a year. According to pilot sample the prevalence of WRMDC was 73% so that the p=0.73, q=0.27, z=95% CI, and e= 0.05 marginal error. According to Health and Health Related Indicators in 2008 by FMOH there were 247 laboratory personnel working in public hospitals in Addis Ababa, Ethiopia (38). The following formula was used to calculate minimum sample size:

$$n_0 = \frac{Z^2_a pq}{E^2} \ldots\ldots\ldots 1\ (eq) \ldots\ldots \text{For Infinite population} = \frac{1.96^{2}*0.73*0.27}{0.05^2} = 302$$

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} \ldots\ldots\ldots 2\ (eq) \ldots\ldots \text{For Finite population} = \frac{302}{1 + \frac{(302-1)}{247}} = 137$$

The 10% non-response rate was 14; the minimum number of sample size was **137+ 14 =151**

Accordingly the study included all laboratory personnel who are fulfilled the criteria from nine hospital laboratories such as Black Lion S.H, Amanuel S.H, St. Paluos S.H, ALERT H, Yekatit 12 H, Zewditu H Ras Desta H, Gandi Memmoral H and Minilek H

Workflow and Laboratory design assessment

The study used purposive sampling techniques for evaluation of laboratory design and workflow in Black Lion Specialized Teaching Hospital Laboratory

5.5 Study Variable

5.5.1 Dependent Variable

- Work-Related Musculoskeletal Disorder Complaints (WRMDC)

5.5.2 Independent Variable

- Sex, age, year of work experience, training, education, marital status, type of jobs, physical activity, standing and sitting hour, house work, laboratory section, workstation.

The status of ergonomics workstation, workflow and laboratory design was also studied in detail.

5.6 Data Collection

5.6.1 Data collection tools

A. Ergonomics workstation and WRMSD

1. Ergonomics Workstation

A standard pre-checked checklist was used to evaluate ergonomics workstation. The checklist was applied for standing bench, seated bench, laboratory chairs, microscopes, pipettes, micromanipulation and computers.

2. **Work-related musculoskeletal disorder**

Work-related musculoskeletal disorder were assessed using pain/discomfort questionnaire, a background questionnaire (containing questions on demographics), and length of time spent in pipetting, microscope workstation, and other regular work tasks.

Personnel Questionnaire: this included the following sections:

- Demographic characteristics (e.g. age, sex, work tenure, educational level, marital status); participants' knowledge of ergonomics; work conditions (e.g. workstation, daily working time, standing and sitting working time, rest pause); occupational history (daily work-shift, time of employment in the institution, the time of employment in the present occupation, the previous performance of the same activity in a different institution, the performance of a second job or overtime work, a previous diagnosis musculoskeletal disorders (WRMSD), a previous diagnosis of rheumatic or bone diseases not related to work), the time spent taking care of children <5 years old, the regular practice of physical exercise or sports and the performance of housekeeping tasks).
- Participants' medical services used in past years (e.g. visiting a doctor, restricted working days and lost working days)

Nordic Musculoskeletal Questionnaire. Using NMQ MSD symptoms during the past year in nine body parts of the participants was surveyed. Using the body discomfort assessment technique, perceived discomfort or pain in the nine body parts were determined on a Yes or No point scale in which Yes and No show discomfort/pain and no discomfort/pain, respectively.

Laboratory Managers' Questionnaire. Laboratory Managers' knowledge of ergonomics and its effects on workplace productivity improvement was studied and a questioner was completed by themselves.

B. **Workflow Assessment**

Standardized checklist and questionnaire was used to assess the workflow of existed automated chemistry laboratory test profile and OPD specimen collection workflow. To assess these the study drawn a map of the sample`s journey using a tool called value stream mapping; spaghetti diagram and record detail of workflow.

Moreover, the team was taken photographs and video of current workflow and motion of work. The teams was analyzed the photographs and video and they were had a chance to realize how disorganized lab and identified gaps that could be proven. Based on this, the team were established a more efficient workflow process.

C. Laboratory Design Assessment

A checklist was used to assess the laboratory design to measure laboratory layout plans, number of section, space, wall, flooring, sinks, chemical and waste storage, furniture design, location and exit paths, lighting, cleanness, electricity, ventilation, emergency eyewash and safety showers, doors and window, caseworks, countertops, water, equipment.

5.6.2 Data collection procedures

A. Work-related musculoskeletal disorder

The principal investigator was briefed about the laboratory work-related musculoskeletal disorder for those eligible laboratory personnel and then the pre-checked self-administer questionnaires was distributed and collected.

Inclusion and excluding criteria

Inclusion criteria:

- The laboratory personnel had fixed day working and had been working more than one year of work tenure at their present workplaces.
- Those who were working on selected laboratory equipment and procedure
- Those who were willing to participant in the study with informed consent form

Excluding criteria:

- Those who were less than one year of work experience at time of study

B. Ergonomics workstation Assessment

In the present study, based on the work type, equipment used and operation similarity, lab workstations were categorized into eight workstations.

Type of workstation was selected

1. Standing Bench
2. Seating bench
3. Laboratory chairs
4. Microscopes: In parasitology, hematology, urine analysis, bacteriology, most of the working time was spent at the microscope. All of them were categorized as microscopy workstations
5. Pipettes: In this workstation, laboratory staff was used pipettes devices
6. Micromanipulation: Vials, forceps, cap openers, tube holders
7. Miscellaneous: Platforms, storage space, cut-outs of storage, bins and racks
8. Computer workstation

Data were captured by trained laboratory personnel and all measurable parameters like the length and width of workstation were collected by ruler, as appropriate the measured value were converted into suitable unit. Direct observation while the lab personnel on work in selected workstation were also gathered.

Scoring workstation evaluation

If the item in the checklist was provided in the workstation it got Yes=1 and if the item was not provided it got a score of No=0. Each "No" answer indicates a risk of injury or sub-optimal condition. The sum of items scores determined the total score of a workstation. The total score of each workstation was divided by the number of items checked and the result was expressed in percent. Therefore, the final score of each workstation was determined by the following table (21).

Table 1 Scoring the workstation evaluation, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

Percent of checked items	Final score	
81-100	5	Ergonomically good condition
61-80	4	
41-60	3	
21-40	2	
0-20	1	Ergonomically poor condition

C. Workflow Assessment

Clinical chemistry laboratory of Black Lion hospital was selected based on large number of test volume analyzed in the previous year. Key tools include: value stream mapping (capture details of process), spaghetti diagrams (map motion); measure times (Cycle time-from beginning to completion and lead time) was used in this study.

A laboratory technologist was dedicated for the project for 4 weeks, assisted by principal investigator. During this period the group was come up with existing detail workflow and identified areas that need change which would be used for developing a new proposed workflow. The next step was proposed a new ideal workflow.

How chemistry tests and sample collection workflow data was captured?

Step-1: Data was collected based on pre-checked checklist on pre-analytical, analytical, and post analytical phases.

Step-2: Data was collected on workflow by interviewing lab staff

Step-3: Detail observational data was collected on workflow process and recorded the whole activities every day using photograph, video and paper

Step-4: The existing workflow motion was drawn by spaghetti tool

Step-4: Each and every single laboratory activities against time were captured by value stream mapping

Step-5: Identified areas that need improvement and cut any wasteful work process

Step-6: Developed new ideal proposed workflow for selected chemistry tests and sample collection workflow

Step-7: New spaghetti workflow motion and value stream mapping was drawn

D. Laboratory Design Assessment

Black Lion Specialized Teaching Hospital was selected based on having various laboratory departments, processed large volume of samples per year, had various workstation, and it was referral laboratory and located in Addis Ababa.

Group of individuals such as engineer, architect, lab manager and principal investigator were worked together in collecting data on the current laboratory design set up using the standard pre-checked checklist. All necessary measurement unit and sketch of laboratory were captured.

5.7 Data Quality Assurance

Pre-tests of questionnaire and checklist were done and revision was made taking into consideration the feedback from non-study participant. Since our study subjects were laboratory personnel and possible to communicate with them by English language, no need of translating questionnaires into Amharic version. Trained laboratory technologists, architect, engineers, and principal investigator were involved in collecting those data and information and delivered every day to data encoder.

5.8 Data Entry and Analysis

Data was entered and cleaned using SPSS version 16 statistical packages and analysis was done. Socio-demographic data were summarized by frequency tables and summary statistics. For all statistical significance tests, the cut- off value set was $p<0.05$ as this was considered statistically reliable for analysis of this study. Proportions, percentages, tables and graphs were used for description of the data as appropriate. Odds ratio with 95% confidence interval was used to identify the factors enhancing the complaint on work related musculoskeletal disorder. The Pearson chi square tests and cross-tabulations were used to assess the statistical significance of associations between complaint on work related musculoskeletal disorder and respondents’ socio-demographic characteristics, laboratory section, main workstation, secondary and overtime jobs, physical activity, previous diagnosis of bond disease, house works, children less than five years, rest between tasks, average standing and sitting hour per day. In the bivariate analyses, crude odds ratios of complaint on work related musculoskeletal disorder were estimated by all covariates. All the covariates were categorical. Since crude OR doesn't take in to account the effect of the confounding variable(s), a multivariate analysis was employed to estimate the adjusted OR of complaint on work related musculoskeletal disorder for suspected confounders and checking for interactions.

5.9 Ethical Considerations

The ethical committee of Addis Ababa University Medical Faculty, Institutional Review Board (IRB) was approved the study. Permission was secured from selected hospitals. All interviews made with study participants was voluntary and any data generated from them was protected their privacy, confidentiality and anonymously. The name of hospital was not mentioned.

5.10 Operational Definition

Block Diagram: graphic illustration of the spaces in a project and how they might fir into a designated area in the facility

Bubble diagram: graphic illustration, using circles, of the required relationships between various spaces in a project

Casework: pre-manufactured cabinet/countertop system

Cycle times: the number of specimens processed per unit of time

Ergonomics: field of study that seeks to fit the job to the person, rather than the person to the job.

Laboratory Design: broad overall plans used to develop and design a process or way of completing work or doing a task.

Laboratory Module: standard distance calculated from two work countertops and the aisle space between them.

Lead time: number of items in process /average completion rate changed process

Leans Systems Approach (LSA): Improves process by identifying each step, removing non-value added steps, and eliminating waste.

Net square meter/Net assignable square meter: usable square meter in a space

Non-value add time: anything that doesn`t add value is waste such as unnecessary activities like long specimen transportation time, waiting time, processing time, motion time, spending time on finding tools or equipment, rework time, etc

Process Cycle Efficiency: Value Add Time/Total Lead Time

Process: A series of steps or actions that produces a completed order or product

Utilities: services, such as gas, electricity, water, drainage, telephone, and data

Value stream mapping: graphical depiction of the sequence of processes for a product and key characteristics of each process).

Value-add time: work that a customer would recognize as necessary to create the product or service they are about to purchase

Ventilation: movement of air into and out of a space

Workflow: the pathway the work follows from the beginning to the end of task

Work-Related Musculoskeletal Disorder (WMSDs): A group of painful disorder of muscles, tendons, and nerves.

6 Results

6.1 Work-Related Musculoskeletal Disorder

Socio-demographic variables

A total of 156 laboratory personnel working at nine public hospitals were involved in the study. The mean age of the participants was 33.96 (SD=8.48) with range of 22 to 54. Of these, 83 (53.2%) were male. Mean work tenure of the participants was 9.27 (SD=6.45). About 93 (59%) of them had more than 5 years of work tenure in their workplaces (Table 2).

Table 2 Demographic characteristic of laboratory personnel working in nine public hospitals, Nov 2011-Feb 2011,Addis Ababa, Ethiopia (n=156).

Variables	Number	Percentage
Sex		
Female	73	46.8
Male	83	53.2
Age in year		
22-32	87	55.8
33-43	43	27.6
44-54	26	16.7
Education		
Certificate	20	12.8
Diploma	41	26.3
Degree	93	59.6
Master	2	1.3
Year of work experience		
1-5	63	40.4
6-10	40	25.6
11-15	23	14.7
>=16	30	19.2
Marital status		
Single	85	54.5
Married	64	41.0
Separated/widowed	7	4.5

Distribution of work-related musculoskeletal disorder by anatomical body part

Our result showed that a total of 336 musculoskeletal complaints in 9 body parts were reported. Of these, feet/ankles 73 (21.7%) and knees 70 (20.8%) were most affected parts of the body and wrist/hand were the least (Figure 1).

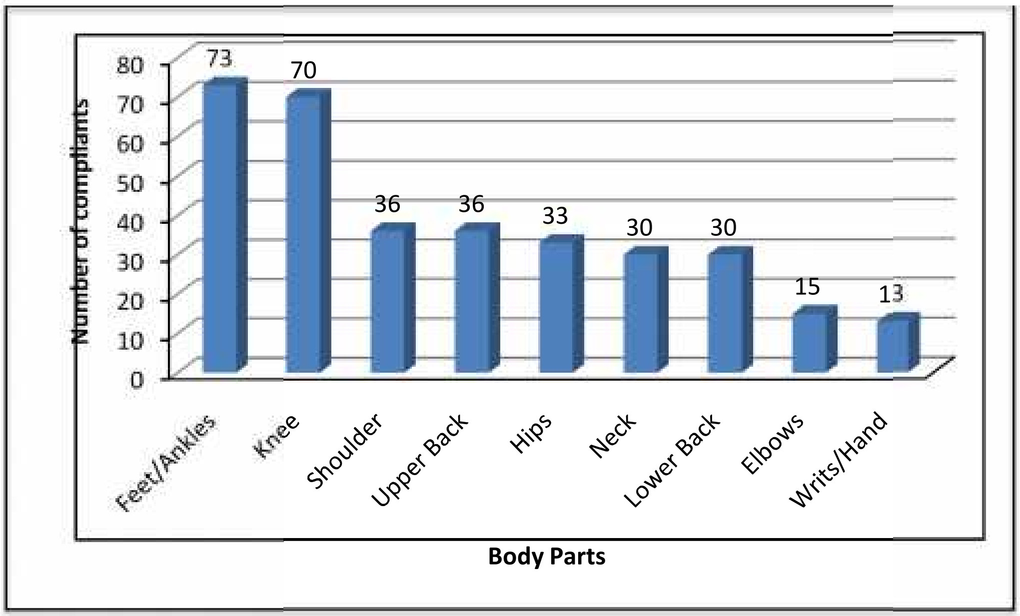

Figure 1 Distribution of musculoskeletal complaints in different body parts in the laboratory staff, Nov 2011-Feb 2011, Addis Ababa, Ethiopia (n=336).

The univariate analysis showed that laboratory personnel working greater than 16 years in laboratory may had high risk of developing WRMSD (OR:41.13; 95% CI (8.7 - 192.3). The study further revelled that the risk of WRMSD among laboratory personnel standing on average between 4 to 6 hours per day were found 2.7 times higher than average standing than 4 hours per day. However, average sitting per day more than 3 hours per day was found protective for WRMSD (OR: 0.503; 95% CI (0.261-0.970) (Table 3).

Age of laboratory personnel in range of 44 to 54 were 58.7 times more risky to WRMSD compared with lesser age group (OR:58.65, 95CI (7.54-455.9). The work-related musculoskeletal complaint was highly associated with poor ergonomic workstation (OR:

61.1, 95% CI (21.0-177.7) (Table 3). Overall the more standing and sitting hours per day may increase number of complaint on work-related musculoskeletal. However, when dependent variable was adjusted for those p-value less than 0.05, poor main workstation was found a major factor contributing for complaint on work-related musculoskeletal disorder (AOR: 268, 95% CI (33.2 -2170.0) (Table 3).

Moreover the data analysis revealed that there was association between compliant and various section of laboratory. Specifically laboratory personnel who were working in bacteriology, ART and parasitology/urinalysis laboratory were more protective for work-related musculoskeletal disorder. However, there were no significant association with previous diagnosis of bone disease, previous jobs, overtime work, secondary jobs, carrying children under 5 years of old, regular house work, regular physical exercise, and rest between tasks (Table 3).

Table 3 Work-related musculoskeletal complaints over explanatory variables in public hospital laboratories of Addis Ababa, Nov 2011-Feb 2011,Addis Ababa, Ethiopia (n=156).

Variables		Dependent Variable: Complaint on WMSD (Count)		Crude odds ratio (95%Cl)	p-value
		Yes	No		
Sex	Female	35	38	1	
	Male	42	41	1.112 (0.593-2.087)	0.741
Age Group	22-32	26	61	1	
	33-43	26	17	3.59(1.671-7.707)	0.001*
	44-54	25	1	58.65(7.54-455.99)	0.000*
Marital status	Single	44	41	1	
	Married	28	36	0.725(0.378-1.391)	0.333
	Separated/Widowed	5	2	2.330(0.428-12.677)	0.328
Educational status	Master	1	1	1	
	Degree	45	48	0.938(0.057-15.440)	0.964
	Diploma	20	21	0.952(0.56-16.279)	0.973
	Certificate	11	8	1.222(0.067-22.401)	0.892
Laboratory section	Clinical chemistry	26	16	1	
	Hematology	26	19	0.782(0.333-1.835)	0.572
	Bacteriology	2	10	0.114(0.022-0.588)	0.009*
	Parasitology & Urinalysis	11	17	0.370(0.139-0.981)	0.046*
	ART	7	14	0.286(0.096-0.855)	0.025*
	Blood Bank	3	3	0.571(0.103-3.172)	0.522
Employee year of experience	1-5	16	47	1	
	6-10	18	22	2.403(1.035-5.581)	0.041*
	11-15	15	8	5.508(1.969-15.407)	0.001*
	>=16	28	2	41.13(8.793-192.34)	0.000*
Main workstation status	Good	15	5	1	
	Poor	74	62	61.173(21.048-177.79)	0.000*
Secondary jobs-Part time job	No	55	53	1	
	Yes	22	26	0.815 (0.412-1.612)	0.557
Overtime work-Duty	No	24	26	1	
	Yes	53	53	1.083(0.553-2.123)	0.816
Previous diagnosis of bond disease	No	61	69	1	
	Yes	16	10	1.810(0.764-4.285)	0.177
Physical activity	No	47	48	1	
	Yes	30	31	0.988(0.519-1.880)	0.971
House works	No	38	39	1	
	Yes	39	40	1.001(0.534-1.875)	0.998
Time spend in home caring children < 5 years	No	63	59	1	
	Yes	14	20	0.656(0.304-1.416)	0.282

Tab, Cont`d

Rest between tasks	Yes	51	51	1	
	No	26	28	1.077(0.557-2.084)	0.826
Average standing hour/day	2-4	25	44	1	
	4-6	41	26	2.755(1.386-5.559)	0.004*
	6-8	11	9	2.151(0.785-5.897)	0.137
Average sitting hour/day	1-3	41	32	1	
	3-6	29	45	0.503(0.261-0.970)	0.040*

The logistic regression model without constant was preferable model to show the musculoskeletal disorder complaints in respect to age and time of employment of lab personnel. The following model generalized that:-

$$Y = e^{-0.083(age) + 0.318(time\ of\ employment)}$$

$$Y = \frac{1}{1 + e^{0.083\ (age)\ -\ 0.318(time\ of\ employment)}}$$

Where; Y = Complaints on work related musculoskeletal disorder, e=constant=2.71828. When the age of laboratory personnel is older by one increased together with the year of experience the complaints on musculoskeletal disorder were also increased. However this is only true that when both variables are increased parallel.

Time of employment, ranged from 2 to 26 and age of employee range from 22 to 54, thus the least record of time of employment and age were 2 and 22 respectively, the log-odds in favour of compliant for musculoskeletal disorder were 0.3 and the probability of complaint were 0.4 (40%). However, if the both factor increased together the log-odds in favours of complaint (44.1) and the probability of compliant were 0.98 (98%). The estimated logistic regression coefficient for time of employment and age were 0.318 and 0.083 respectively and the exponential of this value was $e^{0.318}$ =1.374 and $e^{0.083}$=0.921. This indicated that for a one year increased in work experience and age of employment, the odds in favour of compliant were estimated to be increased by a multiplicative factor of 1.374 and 0.921 respectively.

Our study also showed that 26 (16.7%) of the participant were visited doctors in the past year due to WRMSD. Moreover, 7 (4.5%) of them were reported on a sick leave range from

3 to 10 days. A total of 30 sick leave days were recorded from seven laboratory personnel during last year. The average sick leave for each person was 0.19 days (SD=1.029).

6.2 Ergonomic Workstation Evaluation

A total of 117 ergonomics workstation was evaluated and their final score were determined. Of these 22 (18.8%) and 20 (17.1%) were seating bench and laboratories chair evaluated respectively (Table 4). The overall workstations mean score was 1.95. Moreover, our assessment revealed that 66.6% of workstation found a mean score of two and below which indicate poor ergonomic conditions. In contrast, there were no workstations categorized under good ergonomic condition (Table 5).

Table 4 Distribution of workstation assessed in nine hospitals, Nov 2011-Feb 2011,Addis Ababa, Ethiopia (n=117).

Workstation	N	%
Standing bench	18	15.38
Seating bench	22	18.80
Laboratory chairs	20	17.09
Microscopes	15	12.82
Pipettes	10	8.54
Micromanipulation	8	6.83
Miscellaneous	8	6.83
Computer	16	13.67
Total	117	100

Ergonomics evaluation shown that standing bench and computer workstation was found as poor ergonomics evaluation score. These finding were further supported by almost half of laboratory personnel 77 (49.4%) complaints on work-related musculoskeletal disorder was from mean score below two. This means the lower the workstation score, the more number of musculoskeletal complaints.

More than half of the study participants were work on standing position at least 4 hours per day and 50.3% of participants were also sitting on average greater than 3 hours per day. The mean daily standing and sitting work time were 5.06 hours (SD=1.39) and 3.10 hours

(SD=1.43), respectively. 65.4% of laboratory staff reported not having a rest pause during their daily working time.

Table 5 Mean score evaluation by the type of workstation, Nov 2011-Feb 2011,Addis Ababa, Ethiopia (n=117).

Score	1		2		3		4		5		Mean score	No of workstation	
Workstation	n	%	n	%	n	%	n	%	n	%		n	%
Standing bench	8	44.4	10	55.6	-	-	-	-	-	-	1.56	18	15.4
Seating bench	4	18.2	7	31.8	11	50.0	-	-	-	-	2.32	22	18.8
Laboratory chairs	4	20.0	8	40.0	8	40.0	-	-	-	-	2.2	20	17.1
Microscopes	5	33.3	3	20.0	7	46.7	-	-	-	-	2.13	15	12.8
Pipettes	-	-	6	60.0	4	40.0	-	-	-	-	2.4	10	8.5
Micromanipulation	-	-	3	37.5	-	-	5	62.5	-	-	3.25	8	6.8
Miscellaneous	1	12.5	3	37.5	4	50.0	-	-	-	-	2.38	8	6.8
Computer	4	25.0	12	75.0	-	-	-	-	-	-	1.75	16	13.7
Total	26	22.2*	52	44.4*	34	29.1*	5	4.3*	-	-	-	117	100

**Percents were calculated in proportion to 117 workstation.*

(See page number 16-17, Table 1, how scoring evaluation method done).

In general 20 (12.8%) of the laboratory workers were performing their duties by standing more than 6 hours per day. Relatively, those who were working in chemistry and hematology workstations, 36 and 23 laboratory personnel respectively, were performing tasks in standing position at least 4 hour per day (Table 6). Out of 67 study participants standing more than 5 hours per day had pain on the feet 37 (55%) and knee 38 (56%) were observed, however, no statically significant.

Table 6 Average standing hour per laboratory section, Nov 2011-Feb 2011, Addis Ababa, Ethiopia (n=156).

Average standing hour	Laboratory Section						Total
	Chemistry	Hematolgy	Bacteriology	Para/urina lysis	ART lab	Blood Bank	
2-4	8	22	12	16	5	6	69
4-6	27	17	0	12	11	0	67
6-8	9	6	0	0	5	0	20
Total	44	45	12	28	21	6	156

Ergonomics Awareness

The result showed that 84.6% of the participants were reported never heard about ergonomics. Ninety percent of them declared that they need training on correct working posture and 95 % of them believed that ergonomics principle had to be applied in labs.

Laboratory managers knew little about ergonomics. Most of them believed ergonomics might enhance productivity. They declared there was no ergonomic study or interventional program in their workplaces up to that time.

Standing workstation

There were only 22.2% of them the standing workstation positioned close to elbow height and 38.9% of the laboratory personnel were work their duties with shoulders relaxed. The laboratory personnel (83.3%) were got their primary work tools and supplies located within arm's reach of 4-18 inches. Out of 18 standing workstation assessed 56.6% of them had knee and foot clearance. Only 11.1% of it had a foot rail or foot props and interestingly all standing workstation were not had floor mats in area where prolonged standing tasks are performed. Besides that 89.9% of this workstation had no rounded or padded edges to reduce contact stress.

Seated bench

From the total of 22 seated bench 77.3% of them had cutout available for seated workers. There were 20 laboratories chairs assessed and 20.0% of them were provided with adjustable height and backrests and 60.0% of them had ringed or footrest supported. There were 75% of them had no armrests adjustable or removable if they interfere with work and only 30.0% of operators were known how the laboratory chairs adjusted.

Microscope workstation

A total of 15 microscope workstations were evaluated and 20.0% of laboratory personnel could only view the eyepiece with neutral neck, shoulder and back postures, and 86.7% of the time microscope was positioned within easy reach of the worker that means close to the edge of the workbench. All microscope workstation were not supported with arms support over the bench like books or pad of paper when the operator worked for prolonged period of time and 73.0% of them had sufficient legroom and foot support. However, almost all microscopist were not breaks until the tasks completed during the day time but there were scheduled for work rotation.

Pipettes workstation

Ten pipettes workstation were assessed and 80.0% of the laboratory personnel used the single manual pipetting technique with limited to less than four hours per day and the rest were used multi-channel pipettes. Employees of 10% were trained how they use and selecting appropriate pipettes and 30% of the time racks, trays, breakers and supplies were available and placed within easy reach. Only 10% of laboratory technician were worked in pipette with shoulders relaxed, and arm and wrists in neutral postures.

Micromanipulation

During study period we were able to see some kind of micromanipulation and practice like forcepcing capping and decapping and 75% of the time vials were easily capped and decapped but the rest was a kind of vials that not easy manipulated.

Storage space

37.5 % of laboratories were no had sufficient spaces available for laboratory supplies and only 12.5% of them were heavy bottle and boxes stored on low shelves and temporary platforms were available in two of eight (25%) for tasks that required elevating arms above chest level for prolonged periods.

Computer workstation

Out of 16 computer workstation evaluated only 18.8% were PC monitor parallel to his/her eyes and 75% hadn't glare in monitor screen but there were no glare screens used in all computer assessed. 37.5% of them were operated the pointing device with extended, long duration and repetitive reaching. Furthermore, only 12.5% of them had mouse devices located on the same plane as the keyboard and in a comfortable position and 43.8% of seat chair were height adjustable so that the entire sole of operator foot on footrest. Most of the computer chair (81.3%) had five legs and 37.5% of them were comfortable lighting level on workspace identified.

6.3 Workflow Analysis

Workflow analysis was conducted to assess two main process of laboratory such as specimen collection and chemistry laboratory test workflow.

6.3.1 Specimen Collection Workflow

A total of 708 samples were followed, of these 489 were blood chemistry samples. The study focused on 489 blood samples since commonly patient bloods were aliquots for chemistry and haematology test and both were delivery into respective laboratories together. There were a total of 28 major steps starting from patient test order until delivery of specimen to various departments (Figure 2). The new proposed specimen collection workflow was explained in Annex 3 figure 11.

On average each patient had to wait 40 seconds at the result distribution and payment identification room to know how much amount of money being paid. The patient also waited on average 2.21 minutes at payment office and 6 seconds for verification purpose.

Similarly, a patient should be waited averagely 1.50 minutes at the blood drawing station, and 2.35 minutes were recorded averagely for blood drawing process per patient. Blood collected for haematological tests were left on the mixer for maximum and minimum of 1.05 hour and 2.3 minutes respectively and on average after initial hand mixing the blood left further mixing for 23.32 minutes. A sample was stayed at reception in range of 13.0 minutes to 1.15 hours. On average transcribing hospital ID number into worksheet by manual was 14 seconds per patient form.

To complete the whole process of sample collection workflow for 708 samples, it required a total of 1061.12 minutes. A total of 649.2 minutes were identified as non-value added time from 708 (489 blood samples and 219 other sample). In this workflow non-added value steps were identified and the major were time of patient visit result distribution office and identify the amount of money to be paid per test, patient comeback to the result distribution room for payment confirmation, writing down hospital ID number into worksheet, time spent on delivery of samples, etc (Figure 2).

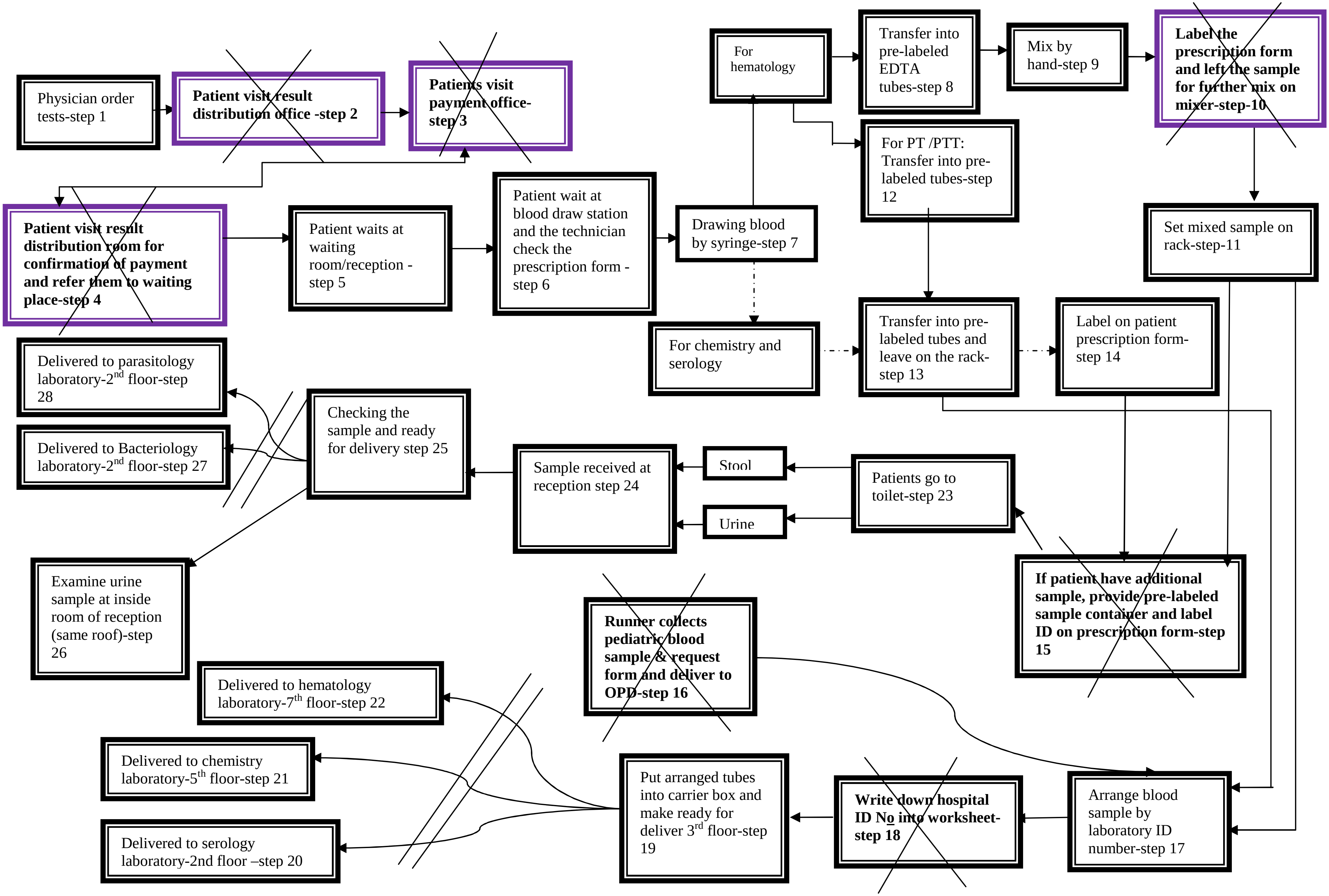

Figure 2 Specimen collection workflow-"AS IS", Black lion Hospital, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

The major contributors for non-value added time were leaving the hematology blood sample for more than 23.32 minute in average, time spent on transportation of sample, writing the hospital ID number into worksheets and collecting and transporting the pediatric samples into OPD reception.

After blood samples draw the average time of waiting at reception prior to delivery were decreased. Figure 3 explained that if few samples, one to ten, were collected, blood samples might be waited more time at reception before delivery to laboratory.

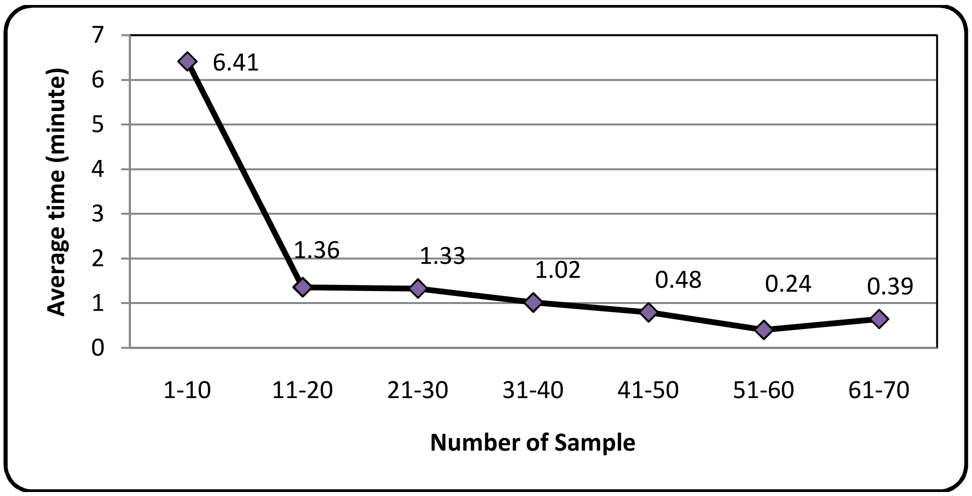

Figure 3 Average time of patient samples waited at reception after blood drew (per minutes), Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

The average patient waiting time after the opening of reception but prior to getting service was 6.06 minutes and the minimum and maximum time of waiting was 2.1 and 14.56 minutes. Most patients waited after opening the reception and prior to present blood drawing station were in range between 2 and 6.0 minutes. Similarly most patients were arrived much early than official opening time of reception and averagely the patient should wait 1.21 hour to get service and with range of 35 minutes (Minimum) to 2.28 hours (Maximum). Only 41.2% (201/489) of samples were got a chance to have the service less than one hour.

The average cycle time of blood draw were defined as the time between the patients called and presented at the draw blood station and end time of leaving blood drawing station. The average cycle times for 489 blood drawing process were 3.58 minutes and 76.5% (374) of patients were provided their blood with an average cycle time of 1.0 to 5.0 minutes (Figure

4). Moreover, the sum of average was 1.15 minutes spent on blood drawing cycle time used for 15 patients as compared to 1 patient that was 2.54 minutes. Besides that 90th percentile of the cycle time and 50th of the cycle time were below 6.41 and 3.39 minutes respectively.

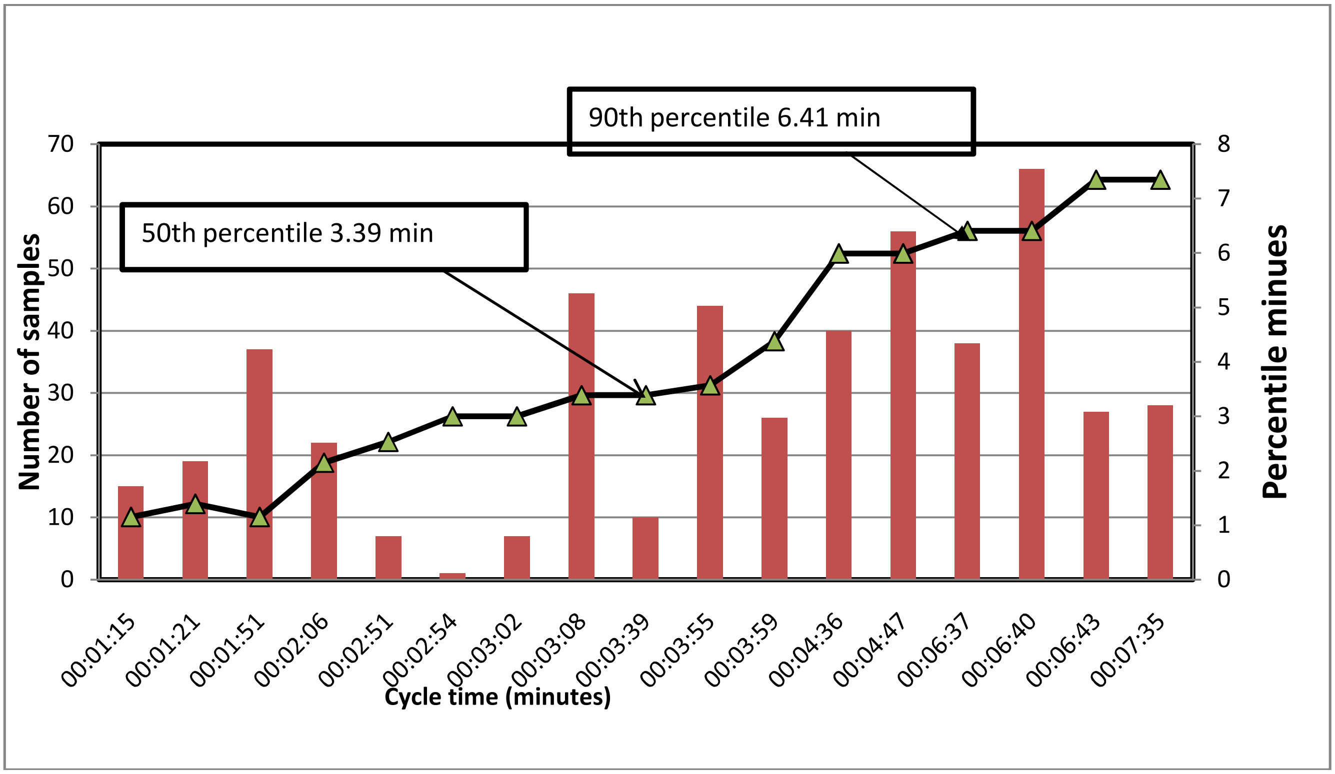

Figure 4 Average cycle time of a patient blood draw process, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

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In average one way delivery of blood samples from reception to serology, chemistry and hematology laboratory section were 2.54, 3.39 and 4.3 minutes respectively. A total of 21.14 minutes (1032 meters) were spent on transportation of sample per deliver into five laboratory sections and collection of pediatric sample (Figure 5).

When sample collection workflow analyzed for chemistry blood samples only excluding the other sample collection workflow, a total of 443.42 minutes were recorded as non-value added time out of 833.19 minutes.

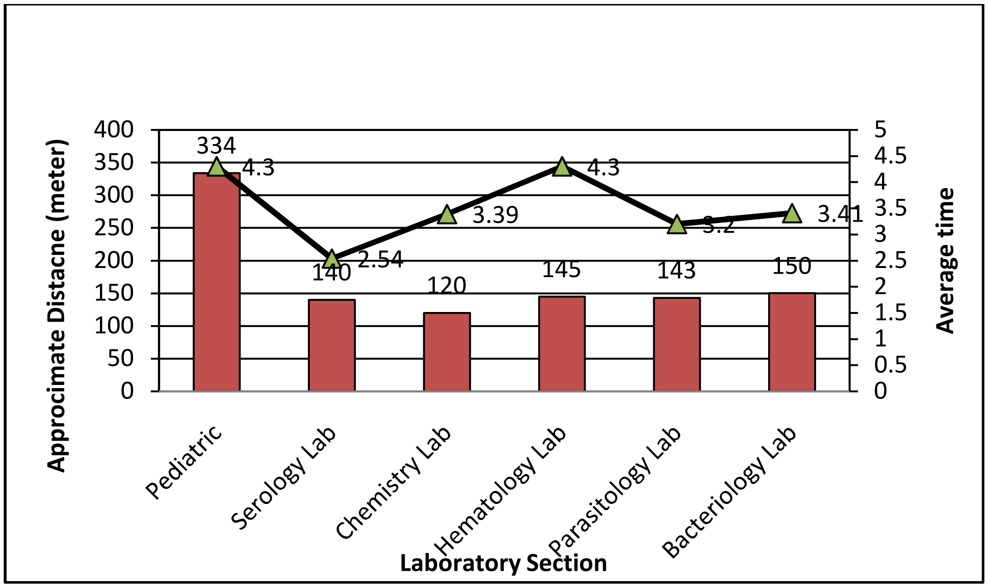

Figure 5 Distance Vs Average time from reception to laboratory sections, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

6.3.2 Chemistry Laboratory Workflow

A total of 489 chemistry blood samples were followed and the minimum number of chemistry blood sample followed was one and the maximum was 66 samples per day. One sample took a total of 15:12 minutes compared with 66 samples which took 6:34 hours start to end (Figure 6). There were 26 major process steps identified by existed workflow and a new proposed workflow was explained in Annex 3 figure 12.

The total time to complete 489 chemistry blood samples after received, analyzed and made result ready for patient were 3025.67 minutes (50.42 hours). Excluding the machine hour (analytical phases), a total of 1771.26 minutes (29.52 hours) were spent on post-analytical phase such as transferring the patient result from worksheet to patient prescription form; copy test result from display (HumanStar 300 machine) to worksheet; enter patient result data into computer or record on log book; print process and paper cutting; verification of patient results, etc and a total of 641.43 minutes (11.09 hours) were utilized by pre-analytical phases such as load centrifuge; arrange centrifuged blood by order; separate and aliquot serum into vials; unload the centrifuge and place tubes to workstation. Therefore, comparatively 58.5% of times were spent on post-analytical phases as compare to 21.2% of pre-analytical phases. The machine hours were relatively smaller by 613.38 (10.21 hours) minutes compared to pre- and post-analytical phases.

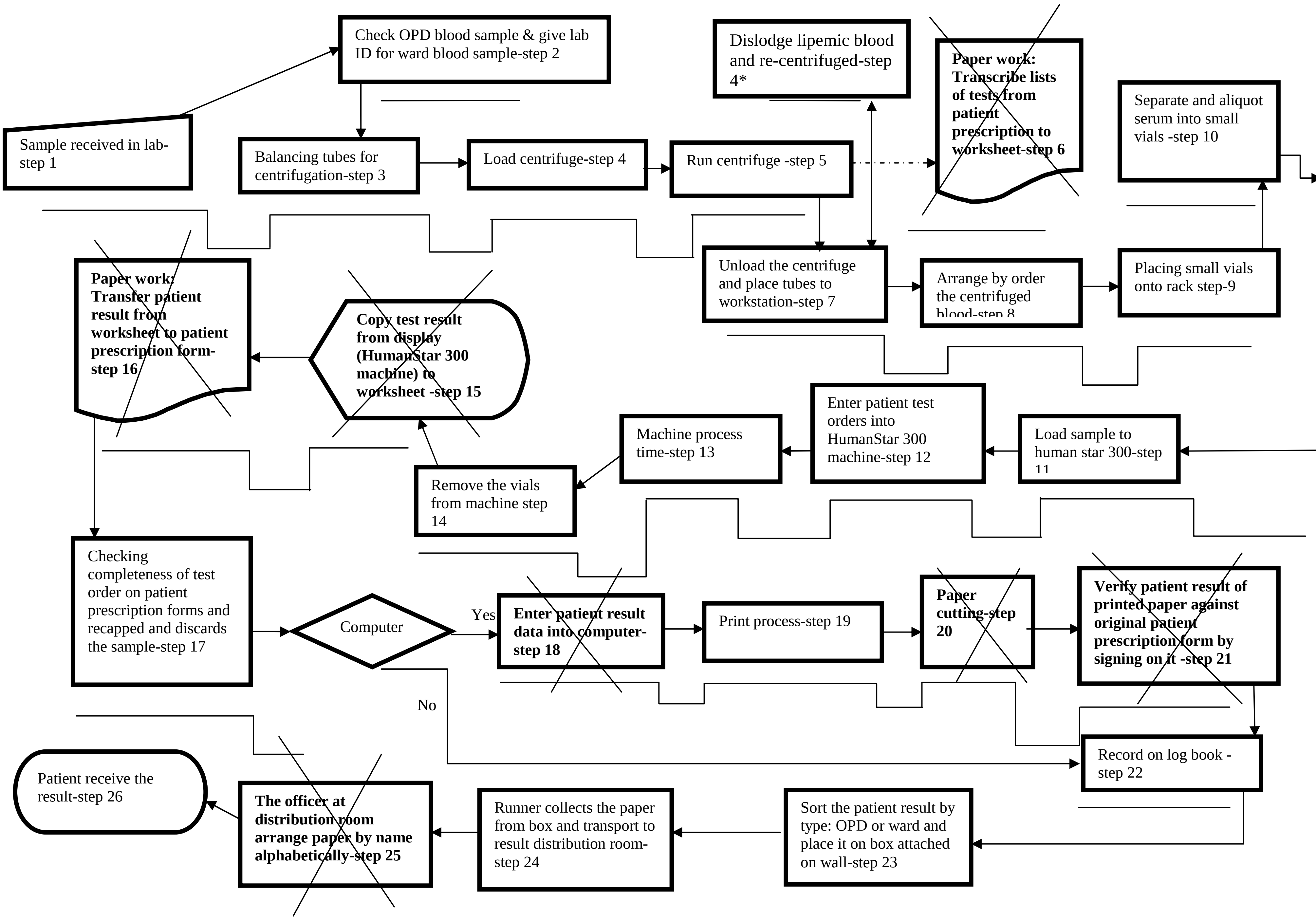

Figure 6 Chemistry laboratory workflow-"AS IS", Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

The technologist walk pattern depicted in figure 7, the non-value added activities were recognized from the movement of laboratory operators where unnecessary movement observed due to the organization of space and design of laboratory. The proposed new spaghetti diagram was presented on Annex 3 figure 10.

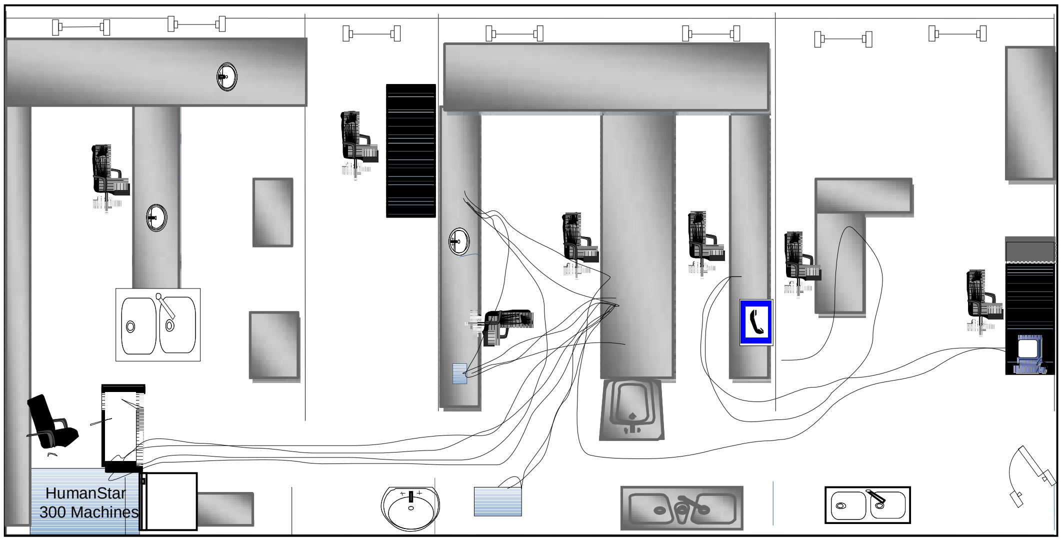

Figure 7 Spaghetti diagram-chemistry blood sample analysis–“AS IS”, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

The workflow of chemistry blood samples test, a total of 1231.31 minutes were identified as non-value added (waste) time from existed workflow and seven non-valued added process steps recognized. This can be explained in terms of unit sample that was 2.51 minutes (1231.31/489) added in each sample which had no value in customer point of view. From total non-added value, 86.7% could explained on post-analytical phases such as copy test result from display (HumanStar 300 machine) to worksheet, transfer patient result from worksheet to patient prescription form, enter patient result data into computer, and verify patient result on printed paper against original patient prescription form by signing on it and paper cutting. The rest (13.3%) non-valued added time were identified on pre-analytical phases such as transcribe lists of tests from patient prescription to worksheet, arrange the centrifuged by blood order.

6.3.3 Chemistry blood test: Cycle and Lead Time

The average cycle time of chemistry blood test is defined as the time of specimen received at the chemistry laboratory and time where the test result ready for runner to be taken. The average cycle time was found 2.46 hours where computerized system was used, however, for manual process the average cycle time were 2.19 hours.

The blood chemistry test lead time were defined as the time where the patient arrive at reception to give blood samples to time where the chemistry laboratory results ready for the patient. The lead time were defined contextually for this study.

The total lead times were 3858.19 minutes and total value-added times for chemistry blood process were 2184.13 minutes. Therefore, the chemistry process cycle efficiency was 56.6%. In other words, only 56.6% of the process was considered value-added to the customer so that the laboratory can increased their value-added percent by eliminating or reducing the waste in the process.

6.4 Laboratory Design

Functional relationship and proximity of laboratory

Black Lion specialized teaching hospital laboratories were located within a complex building structure of hospital. The functional relationship diagram explained the existed laboratory situation (Figure 8). The proposed new laboratories functional relationship diagram was presented on Annex 4 figure 13 and 14.

Based on their location from origin of samples collection areas, Blood Bank laboratory was near and same floor level to that of reception, however, the other laboratories were located at distance. An approximate distance in meter from reception to chemistry, hematology, serology, parasitology, and bacteriology laboratory were 120,145,140,143 and 150 respectively.

Overall the adjoining and adjacent matrix principle were not observed and applied in assessed laboratories. There was no functional relationship between various laboratories.

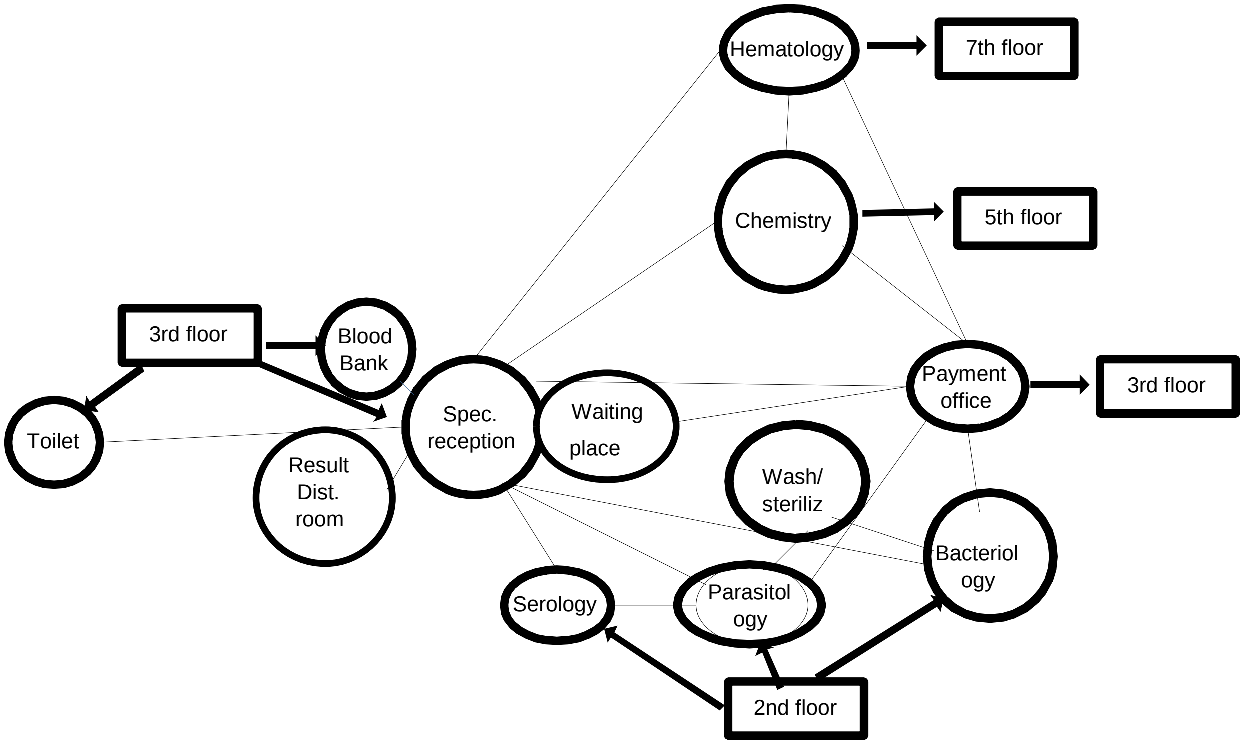

Figure 8 Existed functional relationship diagram of laboratory section at Black Lion Hospital, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

Space

Laboratories didn't have its own mini conference room, no separate office for laboratorians, no separate corridor in accessing laboratory personnel, no free space for expanding its service next to wall, no enough aisles for laboratory equipment for air circulation around them and no functional relationship between laboratory, no flexible space for future use by using flexible casework and also there was unnecessary wall and partition which further compromised the space. Moreover, laboratory was built -locked since the laboratory located inside complex hospital building.

More than half of the black lion hospital laboratories had a wall partition of three which further confronted the adaptability and flexibility of space usage since the design of laboratory was not an open space.

Comparatively chemistry, hematology and bacteriology laboratories were occupied the largest share of total square meter of 149 (23.7%), 138 (21.9%) and 136 (21.5%) respectively from the gross area of 630 Sq. meter (Figure 9).

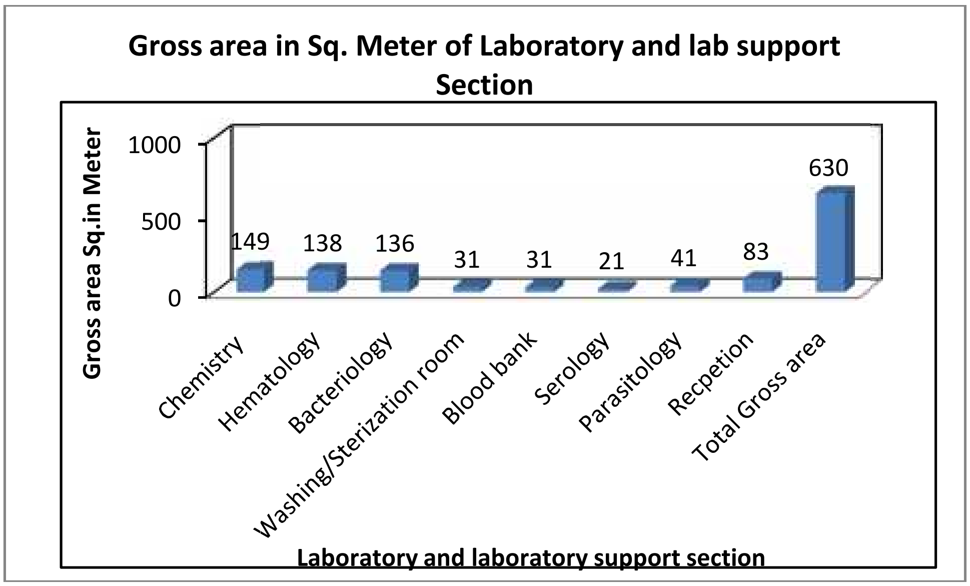

Figure 9 Departmental gross area in Sq. meter of laboratory and its support section, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

Door

There were no lockable doors for security purpose and doors were not closed at all time while an experiment in progress. The main door size of chemistry laboratory was 1.08 meter which was below the minimum standard of 1.2 meter and the interior door of all laboratories were 0.82 meter which still below the minimum of 0.92 meter. All doors were not fitted with vision panels. Except the main door of chemistry laboratory, the other was W: 0.82m and H: 2.0m as like of interior door.

Window

Laboratories window were not installed insect screens, however, all laboratories had found that enough windows for natural lightings and the size of large window was in the range of (W:1.35m,H:1.55m) to (W:1.39m,H:170m) and the small windows in the range between (W:0.55m,H:1.55m) to (W: 0.97m,H:1.55m).

Floor, wall and Ceiling

The laboratory floor were made of non-pervious, one piece and with coverings to wall but the floor was not finished by tiles and wooden planks. The laboratories were not completely separated from outside areas and bounded by four walls. Laboratories ceiling height were in range between 2.75 to 2.90 meters which was below the minimum standard of 3.1 meters. The colour of adjacent walls and ceiling were milky white dark except for bacteriology laboratory that was light yellow.

Sink

A minimum of one laboratory sink was observed in each section of laboratory for hand wishing and almost all where located close to the egress, and each sink had a lip of 0.20 meter. There were an extra sinks in some of laboratories which compromised the net useable space.

Laboratories had a separate hand washing sink with minimum of one and maximum of three and the space was in range of (0.55x0.77) m^2 to (0.75x1.14) m^2. There was large size sink in six (6/8) of laboratory section in the range between (0.43x1.0) m^2 to (0.63x4.80) m^2 and the small sized sink where attached to countertop edge was in the range between (0.64x1.40) m^2 to (0.60x1.60) m^2. Another kind of sink available was countertop sink which was small in size of (0.40x0.46) m^2. Overall the total square of sink from all laboratory section was 30.1Sq.m, of these washing/ sterilization room and chemistry laboratory shared largely by 6.76 and 6.7 Sq. m respectively. Most sink on the countertop were not functional and in average 5 sinks were available in each section of laboratory and the maximum was 12 from chemistry laboratory and the minimum was 2 from serology and parasitology laboratory.

Store room

Laboratory had small size underground cold room storage for non-hazardous materials but no window and sufficient ventilation system was in place. There was no enough chemical storage space available and no separation of chemical by their nature. However, there was hardwood or metal made chemical shelving in mini store room.

Laboratory furniture

As observed almost all laboratory furniture were sturdy but the work surface (bench tops and counters) were not made of impervious to the chemical and they made of wooden.

Lighting system

Laboratories had adequate natural and artificial illumination to ensure sufficient visibility for operational safety except blood bank laboratory had only five functional bulbs out of 13 which were compromised the visibility and safety of operators while working at night. The distance between light fixtures to the work surface were 1.97 meters in average, and the luminaries mounted differently to the work-surface. However, there were some cabinets above the work surface that impend the luminaries. No special lighting systems were installed for emergency exit purpose.

In chemistry laboratory there was 9 bubbles and five were functional and the switching control On/Off were located at entrances and exits door. Five laboratories out of eight had double switched so that depending on the level of illumination desired, half of the tubes may be switched at a time.

During the study period from all laboratory section and support area, 37% (40/108) of bulbs were not functional and location of luminaries were mounted in three different ways such as perpendicular 37.5% (3/7), 29% (2/7) parallel, and 37.5% (3/8) mixed type. Those luminaries mounted perpendicular to the work surface were created a shadow from the person working at the bench.

Casework

The laboratories casework were not built in building, however, they couldn't remove, relocated and reused in the other areas of building. In total six fixed caseworks (not modular) were available from all laboratory section and all was made of wood and outdated style, however, they had the skeleton of gas, vacuum and air outlet but none of them operating, some of them had wiring and electrical connection by function. Their drawers were not working well. Relatively the size of casework was larger than the main door size so that it would not be easy to relocate into other laboratory without separating its components.

Countertop

The edge of laboratory countertop were made of wood core and not rounded. There were no distinct bench type available in all laboratories and the height of seated bench was in average 0.80m which is above the 0.76m of minimum standard. Conversely, the height of standing bench was 0.80m in average which was also below 0.91m minimum standard but knee clearance under sit-down work meet the minimum standard of 0.71m.

Water

Laboratories used two type of water, tap water and distilled water, but there was no centrally located distillation room rather it was installed and placed in hematology laboratory section that served for chemistry laboratory mainly. There was no reservoir tanker dedicated only for laboratory section.

Storage

Concerning storage of flammable liquid there was no separate storage cabinets so that it was placed somewhere in laboratory unit like chemistry laboratory, however, all were displaced below the eye level.

Ventilation system

Laboratories had not any mechanical ventilation system in place and laboratory section had no system of intake the outside air and exhaust to the outside. There were no control system the thermostat of each laboratory.

Electric system

Laboratories had no adequate number of electrical outlets to accommodate additional current requirement, no cover plates and ground system in place; they used electrical cords permanently. In some laboratories section wires were stretched across the floor that might cause electrical hazard. The hospital had backup generator and supply power.

Safety station

Laboratories had no plumed eyewash for all working area during emergency situation and no distinct eyewash safety and shower station installed at edge of the exit door. The laboratory design hadn't shown the direction of evacuation plan during emergency situation and fire extinguisher were not strategically placed and free of obstruction.

Waste storage

Laboratory waste materials were collected from each laboratory section and temporary placed it box of building and gather together transported and incinerated. Incinerator is located within hospital campus.

Therefore, basing the existed situation of Blank lion hospital laboratories and as of referral laboratory, the study proposed new physical layout of laboratories and recommends the minimum clinical laboratory standard whenever laboratory construction and renovation appeared on the stage (see Annex 4).

7 Discussion

7.1 Work-related musculoskeletal and Ergonomics workstation

Regarding work-related musculoskeletal complaints, our study revealed that the main factors for complaints were poor ergonomics workstation, the mean evaluation scores was 1.95, as compared to similar study done in Iran that was 2.21. Furthermore, 22.2% of workstation was score 1 in this study which was contrast to 37.8% below 1 score (21). This could be lack of knowledge about ergonomics and unavailability of ergonomic purchased product.

Our study revealed that the probabilities of compliant on MSD were increased as the laboratory personnel age and year of work experience. Moreover, it also associated with working condition, the worse working conditions, the more musculoskeletal complaints documented.

Our result showed that 84.6% of them ever heard about ergonomics and 93% of participants reported the need of training about ergonomics. In contrast, a study conducted in Iran demonstrated that 83.7% of laboratory personnel were knew about ergonomic and 16.3% of them had a high level of knowledge about ergonomics. Moreover, 60% of participants need training on correct working posture (21). This could be the awareness of ergonomics principle in developing countries including Ethiopia is not in place.

In Ethiopia ergonomics study and its principle has not found its way and proper place yet and is still an unknown discipline. Most ergonomic studies are conducted to reveal costs of neglecting ergonomics principles in the workplace (21). Our study showed that managers are not familiar with ergonomics and its productive applications. It is the only way to encourage employers to support such programs and improve working conditions.

In the present study ten pipettes workstation were assessed and 90% of laboratory personnel were not worked with shoulders relaxed, arms and wrists in neutral postures. Study conducted in Seattle, WA, the technologists were often working in awkward postures due to the length of the pipettes and the height of main workstation. The technologist's head and arms are often held in a forward position with shoulders rounded. Typically, a technologist work with his/her arms unsupported and raised to just below shoulder height (22). This is due to unable to fit the job to you rather fit you to the job due to resource and knowledge problem.

The ergonomic principle should be engineered into laboratory equipment since most workstation was below the standard. Currently, manufacturers are including ergonomic principles in the design of new equipment. Purchasing based on quality; price and ergonomic factors will continue to drive manufacturers of these goods toward designing equipment with the user in mind (23).

In this study work -related musculoskeletal complaints disorder was observed on ankle/feet and knee. However, study done in Iran showed that lower back, neck and knee were the major compliant found. The difference could be the use of non-identical workstation type used in two studies (21).

7.2 Workflow Analysis

A total of 649.2 minutes were recognized as non-value added time from 708 samples from current specimen collection workflow. Similar study done in New Jersey, US hospital, BD diagnostic service, the current state consisted of 19 steps, five of which were at risk for specimen identification errors, and three of which were causing unnecessary delays in the specimen collection workflow. The value stream mapping showed that the total value-added time per day (based on 616 blood specimen collections/day) was 2264.3 minutes, while the non value-added time was 1018.5 minutes (27, 28). This cloud explained as there were not used quality management system and not customer based service provided.

In our study standing blood samples for long period of time until enough number of samples aggregated were documented. As example blood collected for hematological test was left on mixer extra mixing procedure in range of 2.3 minutes to 1.05 hours. According to the clinical and laboratory standard institute (CLSI) recommendation that primary tubes that contain additive should be gently mixed 5 to 10 times (less than 30 seconds) to allow a complete interaction between blood and anticoagulant (24). Therefore, the effect of prolonged mixing of hematological test can be studied and used for improvement.

The study confirmed that at the pick time of a day the reception should deployed more staff and experienced phlebotomist should be selected for effective time management, and producing reliable and accurate test result since prolonged blood drawing process had direct effect on test measurement. Therefore, the laboratory shall scheduled ahead of time who is going to collect samples since as observed and recognized there were some student in practices or other unqualified personnel involved in the blood drawing process which greatly affect the test result, workflow and turnaround time.

Patients were waited on average between 35 minutes and 2.28 hours. Even if the reception usually opened between 8:20 to 8:30AM, the opening hour of reception in every day was inconsistent. The blood drawing station was three and they were small in size, poor ergonomic workstation used, physical layout and space was not organized. In other study stated that their outpatient phlebotomy clinic was small in space size but had five drawing stations and patients arrive without appointments are seen on a first-come, first-served basis. Wait times were inconsistent; some patients were seen almost on arrival, but others waited 30 to 40 minutes, or longer. The analysis found an imbalance between demand and staffing, especially early in the day. Patients arriving before the actual opening time caused a backlog that had a ripple effect lasting into the morning. To address that, the team decided to open the centre 30 minutes earlier and increase staffing during the morning hours (26).

Our study revealed that the flow coordinator coordinates the flow basing patient arrival time (first-come, first serve), and patients who had urine and stool were provided they their samples after blood drawing completed. However, study done in Brigham and Women's Hospital shown that those patients need urine/stool testing provided their specimens collected in the interval between arrival and blood draws (25).

The following were recognized as area of improvement on samples collection workflow such as opening the reception before 30 minutes; assigned flow coordinator everyday; develop a ways for phlebotomist in reduce non-blood drawing activity; use barcode label system, use unique laboratory ID number, make available all collection kits prior collection start; reconfiguring blood drawing station, use ergonomically phlebotomy workstation, change the physical layout of reception, etc. Study done in Brigham and women's hospital, Boston shown that the following opportunities were identified during the pre-lean period: non–blood-drawing activities decreased the amount of time phlebotomists could devote to their patients, patients often arrived before the opening of the phlebotomy station, creating a backlog at the beginning of the day that increased wait time, because patients were not aware of their "place in line," staff sometimes had difficulty identifying and finding the next patient when it was his or her turn (25).

Our finding revealed that the average patient waiting time after the opening of reception and prior to blood drawing station was 6.06 minutes and patient waiting time in term of pick hour of a day (usually in the morning-high number of samples) and in the middle of day (less number of samples) were 14.56 and 2.1 minutes respectively. Other study explained that an average patient wait time during a high volume period was 21 minutes. Collecting urine specimens before the blood draw helped decrease wait time. For patients requiring urine collection, the wait time was reduced by 20%. The percentage of time spent performing non–value-added tasks decreased, which also contributed to shorter wait times (27).

In our study the average cycle time of blood drawing process was 3.58 and this cycle time were highly depend on how experienced phlebotomist at stage, effective coordination of workflow and number of staff available at pick hour, not necessary depend on number of patients present at time. By modifying the existed workflow using lean principle and creating good ergonomic workstation together with modifying the physical layout of reception, the process cycle efficiency can be increased more than 56.6%. Hence, similar study done Brigham and Women's Hospital revealed that as cycle times are reduced, productivity increases proportionally and 50% reduction in cycle time (25).

Our assessment revealed that an average of 2.54, 3.39, and 4.3 minutes was spent delivery of samples to serology, chemistry, and haematology laboratory unit respectively. This was due to proximity problem and understanding their functional relationship between them. (26).

Only from chemistry workflow a total of 1231 minutes were identified as non-value added (waste) time and 86.7% of the time was explained on post-analytical phases. Therefore the study identified that the major waste was from post-and pre-analytical process and by modifying the workflow and physical layout of laboratory it's sure that those waste can be reduced and increase productivity and reduce unnecessary.

To improve the current workflow of specimen collection and chemistry laboratory; to reduce the cycle time and to increase the productivity , the study strongly suggest that Black Lion hospital laboratories should applied quality management system and look the new quality improvement model like lean model to achieve the customer need. Several medical centres are already publishing their successes with the institution of quality improvements in patient care using such techniques. Likewise, clinical laboratories and consulting industries are migrating to improve quality in an increasingly complex system and at the same time reduce cost (29).

7.3 Laboratory Design

Black Lion hospital laboratories revealed that the functional relationships between different laboratories unit and its proximity principle (adjacency and adjoining) were not in accordance with standard. There was no functional relationship observed between various laboratory sections. In designing of laboratory, functional relationship should be developed before initiation of construction or renovation. Hence, appropriate relationships and adjacencies are essential to permit a smooth flow of personnel, supplies, and equipment. Workflow is highly depending on the physical layout of laboratories and its proximity. It is important that the distance between laboratories, reception, and common instrument rooms be as short as possible since samples, chemicals, and flammable materials are transported between the theses areas (3, 30, 37).

Concerning the laboratory design, the study identified that almost all laboratories were not had a separate office for laboratory workers, no mini conference space available, no flexible space for future use, no flexible casework, unnecessary wall and partition, no free space for expanding its service next to wall, no enough aisles around equipments, and the laboratory was not completely separated from outside areas. As clinical laboratory standards, all laboratories and non-laboratories works should be separated (31, 37).

All laboratory doors were not self-lockable and had no vision panels and the main door size was below the minimum standards. Moreover, there was no exit door for emergency evacuation plan, operator forced to use entrance door during emergency and all laboratories main doors were swing into the laboratory. However, doors should swing out from laboratories as a means of safe egress if corridors are wide enough; but it can create hazardous conditions by blocking the corridor traffic if not recessed into an alcove. For new construction or renovation of laboratory, 1.8 meter wide corridors, 1.2 meter door widths are appropriate permitting larger equipment to be moved into the laboratory (31).

Almost all laboratories had adequate natural and artificial illumination to ensure sufficient visibility for operational safety procedures except for blood bank laboratory. However, the location of luminaries was not in similar fashion, some of them were perpendicular, parallel or mixed type. In general, the more detailed task as of bacteriology laboratory, the higher the illumination required to perform it with accuracy. Where the correct identification of colour is important, special colour-corrected lamps may be necessary (32, 3).

The assessed laboratory had no mechanical ventilation system and no adequate number of electrical outlets to accommodate additional current requirement, no ground system and cover plates. The laboratory didn’t have an emergency evacuation exit door in placed (33, 37).

Since Back lion hospital laboratories were not an opened plan, many wall partitions together with unstandardized lab module type were recognized. In order to achieve flexibility, the design must be planned in terms of a basic planning concept, "the laboratory module". The module establishes a dimensioned method by which building systems, partitions, and casework work well together within the new or existing building structural framework. Whenever new design of laboratory construction or renovation is in place, cost savings proposals must be investigated during the process of planning. Partitions used within laboratories to hang casework may be replaced by free-standing cabinets and shelving (34, 35, 37).

Our study explained that laboratories accumulated non-functional equipment which compromised the existed space and these indicated that through time newly arrived equipment has been added over and over in the same room. Thus, critical information regarding equipment needs and operations is required for each laboratory unit early in the design phase of the project but taking the future expandability of service into consideration, the design should incorporate free space. Equipment selection and location should be finalized early in the design stage to avoid redesign and schedule delays (36).

There was no safety stations identified at Black lion hospital laboratories such as emergency shower and eye washer. Emergency showers are located in the hallways with a contrasting spot painted on the floor to indicate the shower location, with the number of showers per area to be based on Occupational Health and Safety Agency (OSHA) requirements (30).

8 Limitation of the study

- The major limitation of this study was unable to get enough literature materials regarding ergonomic, workflow and laboratory design.
- Since a study was a cross sectional we were not able to document and measure the proposed new workflow. .

9 Conclusion

- ✓ Work-related musculoskeletal complaint was strongly associated with poor ergonomic workstation.
- ✓ Overall the more standing and sitting hours per day increased number of complain on work-related musculoskeletal.
- ✓ Majority of study participant reported that never heard about ergonomics.
- ✓ A one year increased in work experience and age of employment, the odds in favour of compliant were found to be increased.
- ✓ The non-value added time was 649.2 minutes out of 1061 minutes of 708 samples followed.
- ✓ Most patients were arrived much early than official opening time of reception and on average the patient waited 1.21 hour to get service and with range of 35 minutes to 2.28 hours.
- ✓ The average cycle times of blood drawing process of 489 samples were 3.58 minutes and 76.5% (374) of blood were drawn within an average cycle time of 1.0 to 5.0 minutes.
- ✓ Only from the workflow of chemistry blood samples test, a total of 1231.31 minutes were identified as non-value added (waste) time from current workflow and seven non-valued added process steps recognized.
- ✓ Only 56.6% of chemistry process was considered value-added.
- ✓ The adjoining and adjacent matrix principle were not observed and applied in assessed laboratories.
- ✓ Laboratories were not had its own mini conference room, no separate office for laboratorians, no separate corridor in accessing laboratory personnel by public access, no free space for expanding its service next to wall, no enough aisles between laboratory equipment for air circulation around them, no functional relationship between the existed laboratory location, no flexible space for future use by using flexible casework.
- ✓ Almost all main door size of Black lion hospital laboratory was below the minimum standard of 1.2 meter and all interior doors of all laboratories were also below the minimum of 0.92 meter.

- ✓ The laboratory design hadn’t shown the direction of evacuation plan during emergency situation and fire extinguisher were not strategically placed and free of obstruction.
- ✓ Black lion hospital laboratories were not had any mechanical ventilation system developed and laboratory sections not used 100% outside air and exhaust it.
- ✓ The countertops were aged and fade and some were broken.
- ✓ There was no eyewash or shower safety location in any of laboratory section accessed.
- ✓ There were different way of mounted light fixture in a single laboratories observed such as some of them perpendicular or parallel or mixed.
- ✓ Laboratories had no adequate number of electrical outlets to accommodate additional current requirement, no cover plates and ground system; they used electrical cords permanently that was not recommended ways.
- ✓ There was no emergency lighting system in this hospital laboratory design.
- ✓ The laboratory design was not allowed the casework utilities to be flexible since changes will require walls to be opened or floor to be drilled.

10 Recommendation

- Ergonomics awareness for laboratory professional should initiate how neutral working posture maintain to prevent work-related musculoskeletal disorders
- Whenever laboratory and office equipment ordered to purchase, institute shall make specification concerning ergonomics application together with quality and cost.
- Laboratory personnel shall reconfigure or redesign or reposition his/her workstation or laboratory equipment to fit the work to you not the work to fit to you.
- Laboratory personnel should reposition tools and supplies within close reach, modify bench surface with clamp on the cut out to increase knee and foot clearance, provide temporary standing platforms, remove supplies and equipment from bench cut out area, provide floor mats, redesign work to reduce movement between stations to optimize workflow, provide arm supports for stability if not available, provide adjustable work platforms to position work at optimal height, provide chair with foot rings, provide footrests, adjust armrest to provide support with shoulders in neutral postures, adjust posture/seat height/seat angle, use arm support/pad, reposition microscope, reposition worker, work rotation, work breaks, consider use of alternative pipettes, provide employee posture training, provide adjustable chair, etc
- Providing basic training about ergonomics for laboratory personnel.
- Hospital outpatient reception should be opened earlier at least 30 minutes prior to official opening hour to prevent backlog and add additional staff to reception during pick hour of a day
- Identify and select one staff to be work as flow coordinator and provide him/her training on it
- Use the new business improvement tools like lean in laboratory to reduce waste like reduce unnecessary movement, paper works, etc
- Eliminate any non-value activities or process, work only on value-added process to lead laboratory industry and satisfy the customer.
- When laboratory design initiate the adjoining and adjacent matrix principle should be look in detail

- During the planning programming phase of laboratory design the team should involved laboratory manager, architect, engineer, administrator and other relevant individuals
- Detail laboratory equipments, aisles, casework and countertops should be calculated and identified the current number of test volume, number of staff, workflow, lean laboratory design system,
- All the laboratory safe issue during design laboratory should be considers
- All lighting and electric system and plumbing system should be studies in detail and follow the clinical laboratory standards while designing laboratory
- An open plan laboratory system may be better and use laboratory module method in design laboratory
- Great attention need for safety station and exit doors, evacuation plan should be identified
- All control access of laboratory gate and door should be in place to prevent visitors and patient entrance
- Mechanical ventilation system should be placed in laboratory and laboratory support areas
- Using lean techniques to identified the place of laboratory equipment, fume hood, biosafety cabinets, caseworks, countertop, sinks, etc and to determine the required space before design the laboratory

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Annex 1 Laboratory working posture on various workstations, November 2010, Addis Ababa, Ethiopia.

 31		
A. Contact stress (seat at edged)	B. Arms contact with rough bench edged	C. No backrest and adjustable armrest
		
D. Shoulder bend	E. Microscope workstation: not neutral head, neck, shoulders and arm postures	F. Microscope workstation: arm unsupported
		
G. Pipette workstation: knee clearance depth less than the operator legs	H:Unadjustable and fixed countertop	I.Unmovable four legs chair
		
J. supplies under bench compromised knee clearance	K. Wrong standing posture	L. Inappropriate storage and insufficient space

		
M. Foot and knee clearance compromised	N. Non-functional drawer	O. Microscope workstation with unadjustable chair
		
P. Foot rest available	Q. Laboratory bench used for computer workstation	R. Wrong ways of sitting
		
S. Foot and knee clearance cluttered with supplies or equipment	T. Microscope workstation: problem of knee clearance and opened drawer and un adjusted chair	W. No backrest and door opened to find knee and foot clearance

Annex 2 Laboratory design substandard at Black lion hospital laboratories, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

A: Wall below sink non-ceramic

E: Electrical wires

B: Pluming system

F:Non-ceramic wall

C: Fire extinguisher in middle of laboratory

G: Storage problem

D: Casework wires: no utility core

H:Color of wall and ceiling

I: Water Tanker in side lab-deign effect

K: Narrow main door

J: Flowers on countertop

Annex 3 Proposed workflow

In figure 11 shown that the ideal workflows of specimen collection were reduced into 20 steps compared from the old workflow which had 28 steps. The modified workflow could save much time by shorting the workflow which had no value for customer since the operator spent more time on it.

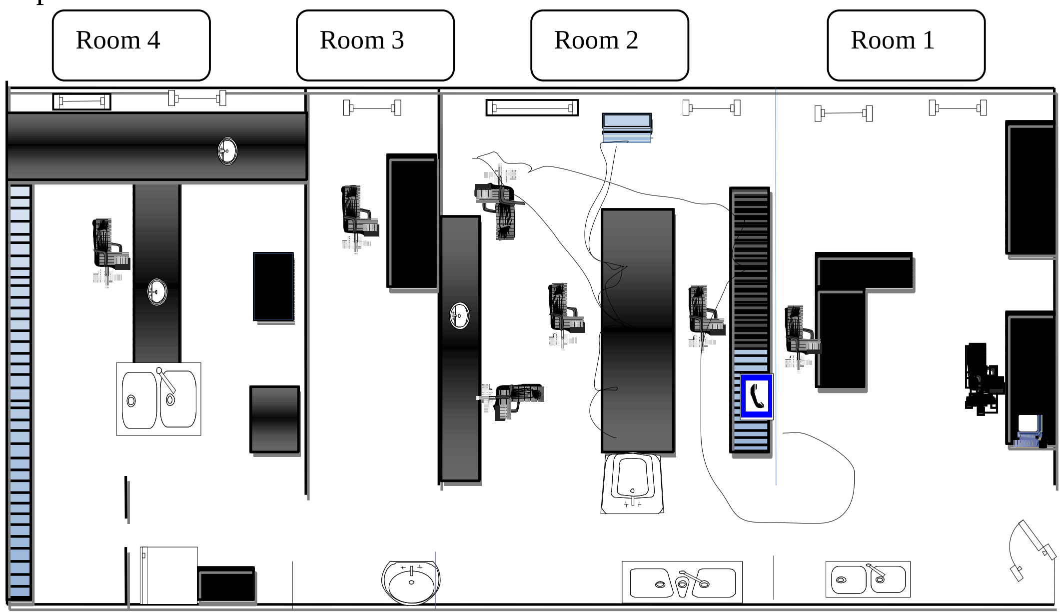

Figure 10 Ideal Spaghetti diagram-chemistry blood sample analysis–"TO BE", Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

The movements of operator's every day were the same; the study acknowledged there was a room for improvement by modifying the workstation by removing the bench that attached with wall (Room 2) (Figure 10). Therefore, it would be sure that the movement of operator can be reduced significantly into five steps as compared 17 steps of movement that was recorded on existed workflow and twelve steps movements were considered as wastes. In terms of time, approximately 2.0 minutes were saved in every batch of test run.

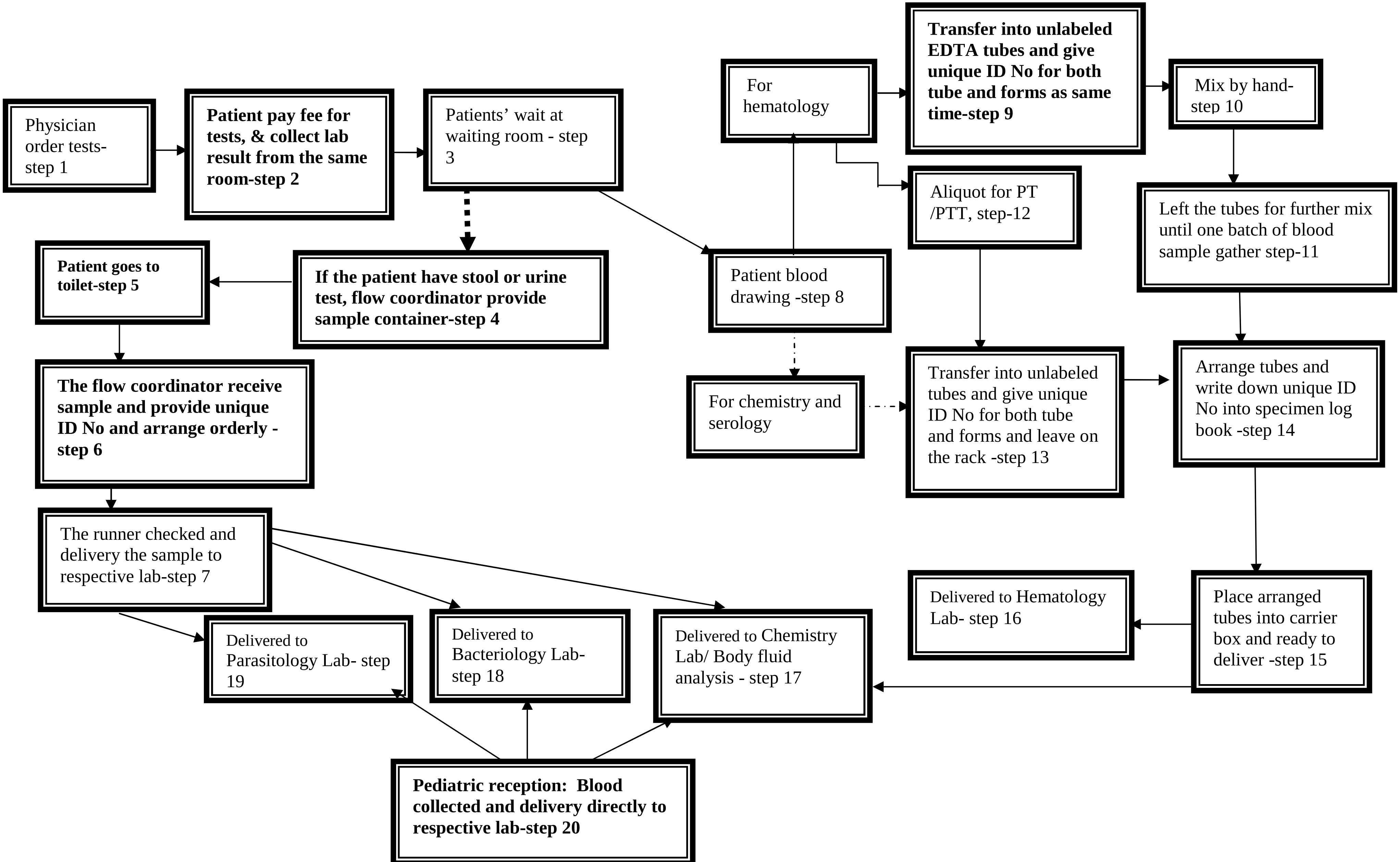

Figure 11 New ideal Sample collection workflow-Black Lion Hospital-"TO BE", Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

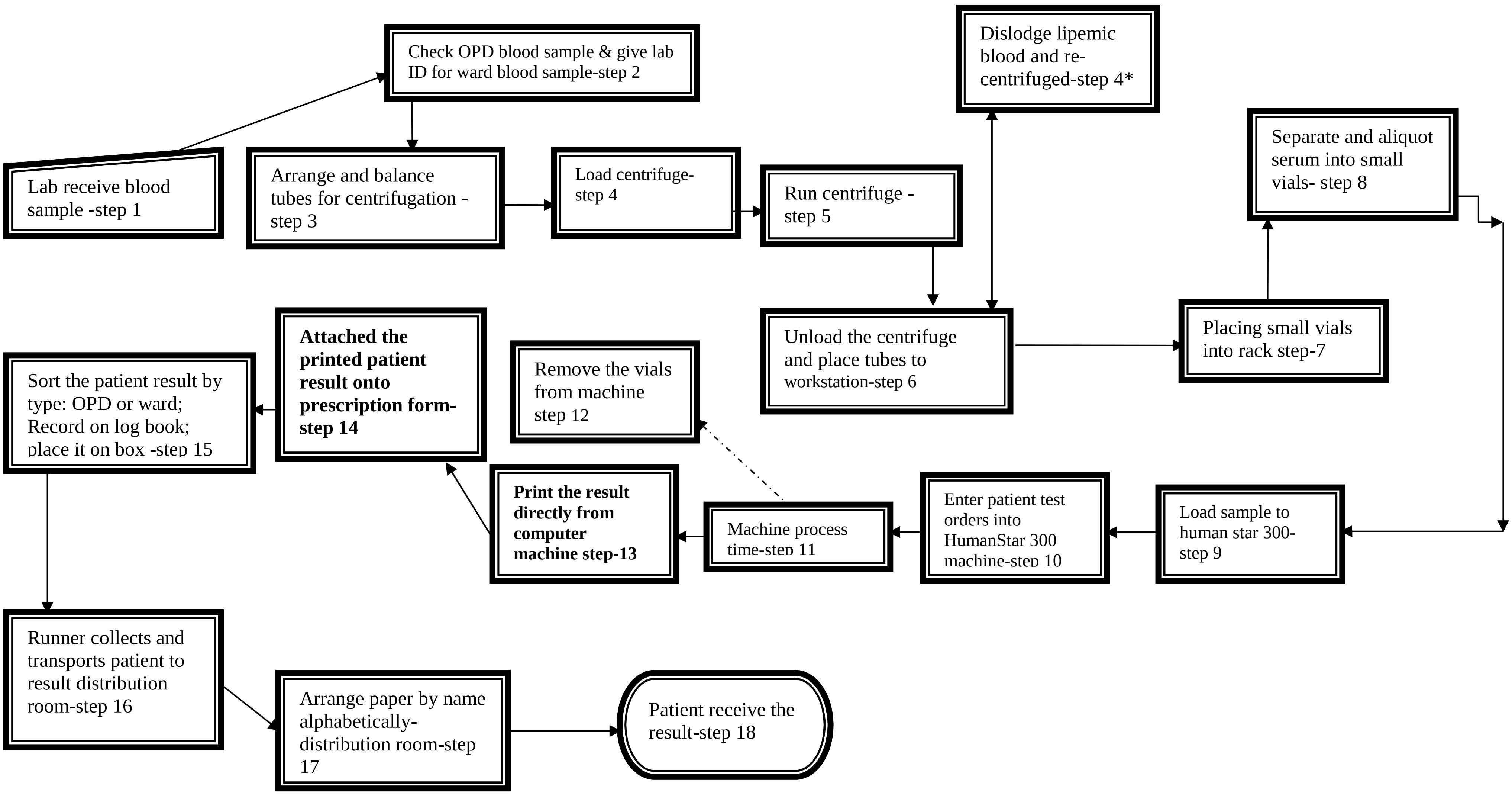

Figure 12 New proposed Clinical Chemistry test Workflow-Black Lion Hospital-“To Be”, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

Annex 4 Proposed laboratory design

Since the existed laboratories proximity functional relationship were far behind from the current clinical laboratory standard proximity illustrate graphically below (Figure 13) and also the block diagram presented here and its general floor plans that show the laboratory spaces as one block of space (Figure 14). Figure 14 is not shown clearly the doors, location of equipment or casework shown at this stage (planning and programming phase). However, it illustrates the various option of how the laboratory space listed in the program can fit in the area or areas chosen for it. In addition it shows the generalized movement of the samples, staff, supplies, waste and patient entrance.

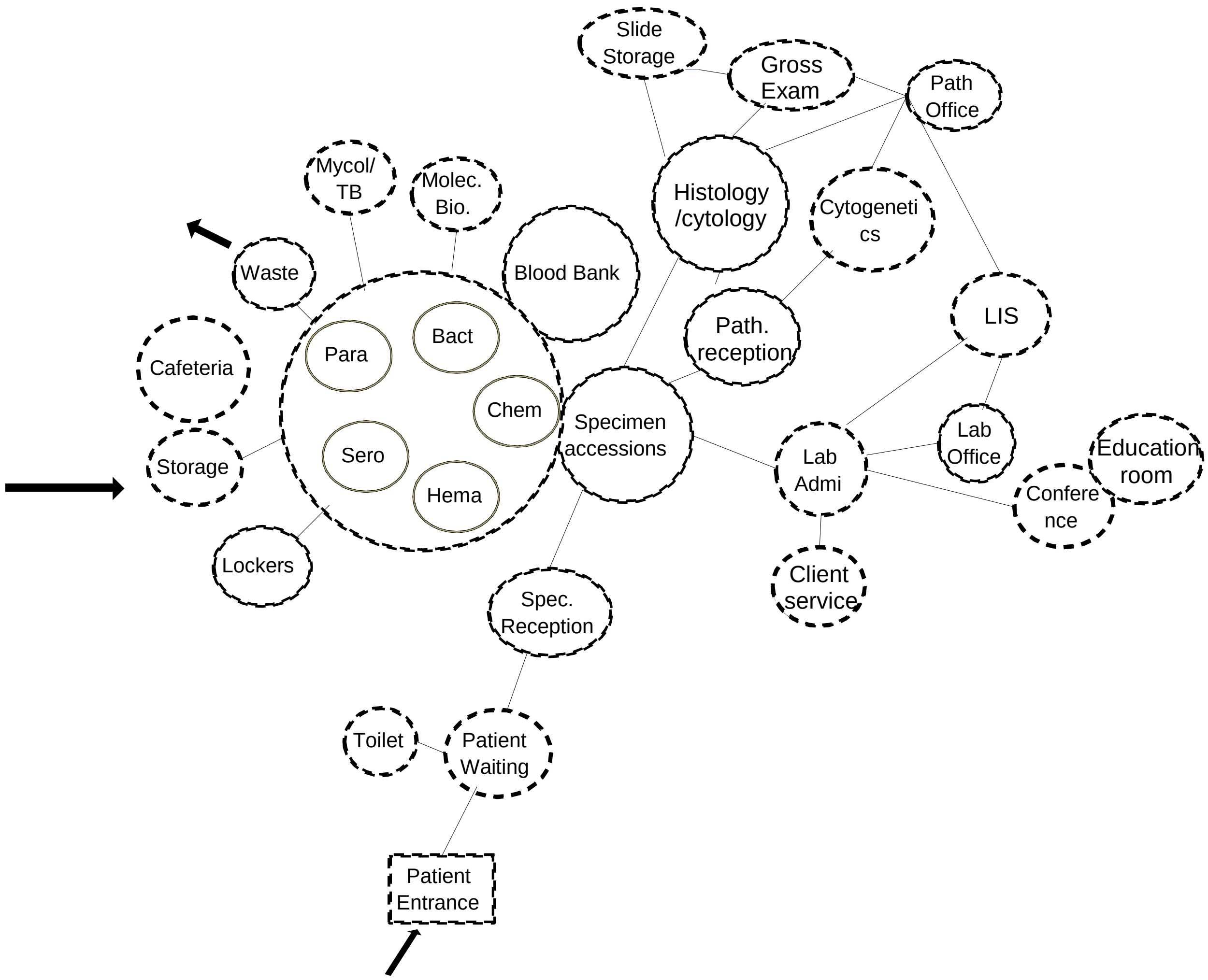

Figure 13 Proximity programming and functional relationship diagram, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

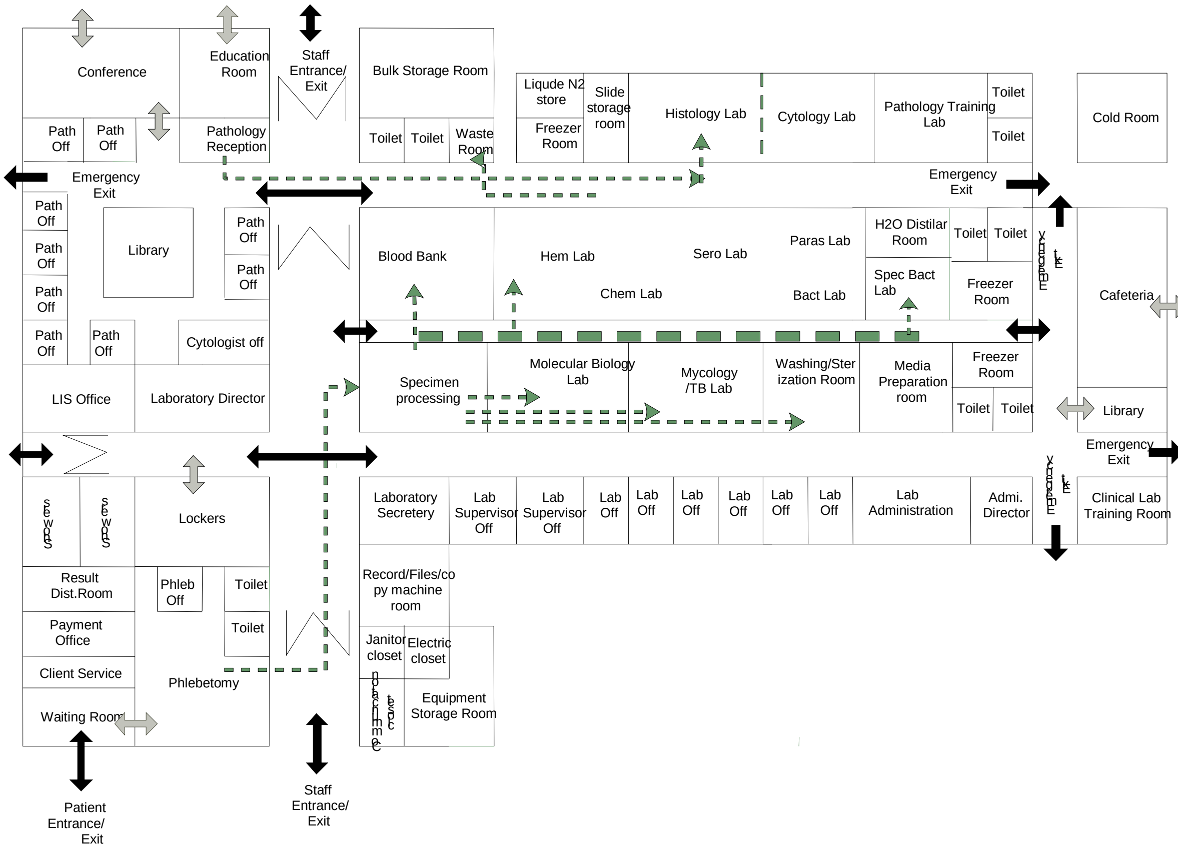

Figure 14 Proposed Hospital Laboratories Block /Movement Diagram, Nov 2011-Feb **2011,**Addis Ababa, Ethiopia.

Based on the evaluation of laboratory design of Black lion hospital laboratory, the study determined the physical layout based on its size and by the nature and number of clinical tests that performed currently and future will be performed. It usually resembles a combination analytical chemistry and biological laboratory. The necessary space for a particular laboratory requires an understanding of all its functions.

Floor space determination

Laboratory features that are required by regulatory and accreditation agencies need to be addressed when determining square footage. These includes fixtures such as emergency eyewash stations, emergency floor, showers, hands wash sinks, and fire extinguisher cabinets. Space must be allowed for ease of manoeuvring throughout the laboratory, including the area between casework, in aisles, and around equipment.

Laboratory module: A single laboratory module is defined as a basic unit of space of a size commonly referred to as a two-person laboratory. A typical laboratory module is between 10 to 11 feet (3.10 to 3.35 meter) (Figure 15 &16). The 10-foot module includes countertop of 30 inches (0.76m) on each side and an aisle of 60 inches (1.52m). The 11-foot module has the same countertops and aisle, but also incorporates the utility core that is typical for many laboratory casework systems. This core is 12 inches (0.31m), and the module assumes half of the core each side for a series of counters.

The length of laboratory module is governed by several variables: the overall width of the building enclosure, the area allotment for a standard module. Laboratory module length is generally 20 to 30 feet for the efficient operation of the laboratory. Laboratory length in excess of 35 feet may generate egress problems.

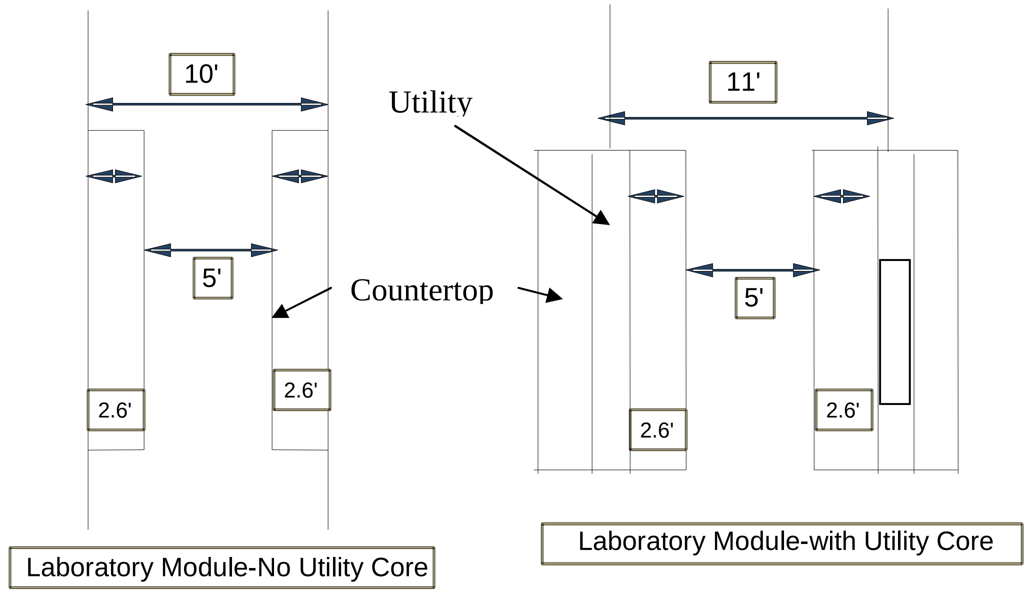

Figure 15 Typical Clinical Laboratory Module, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

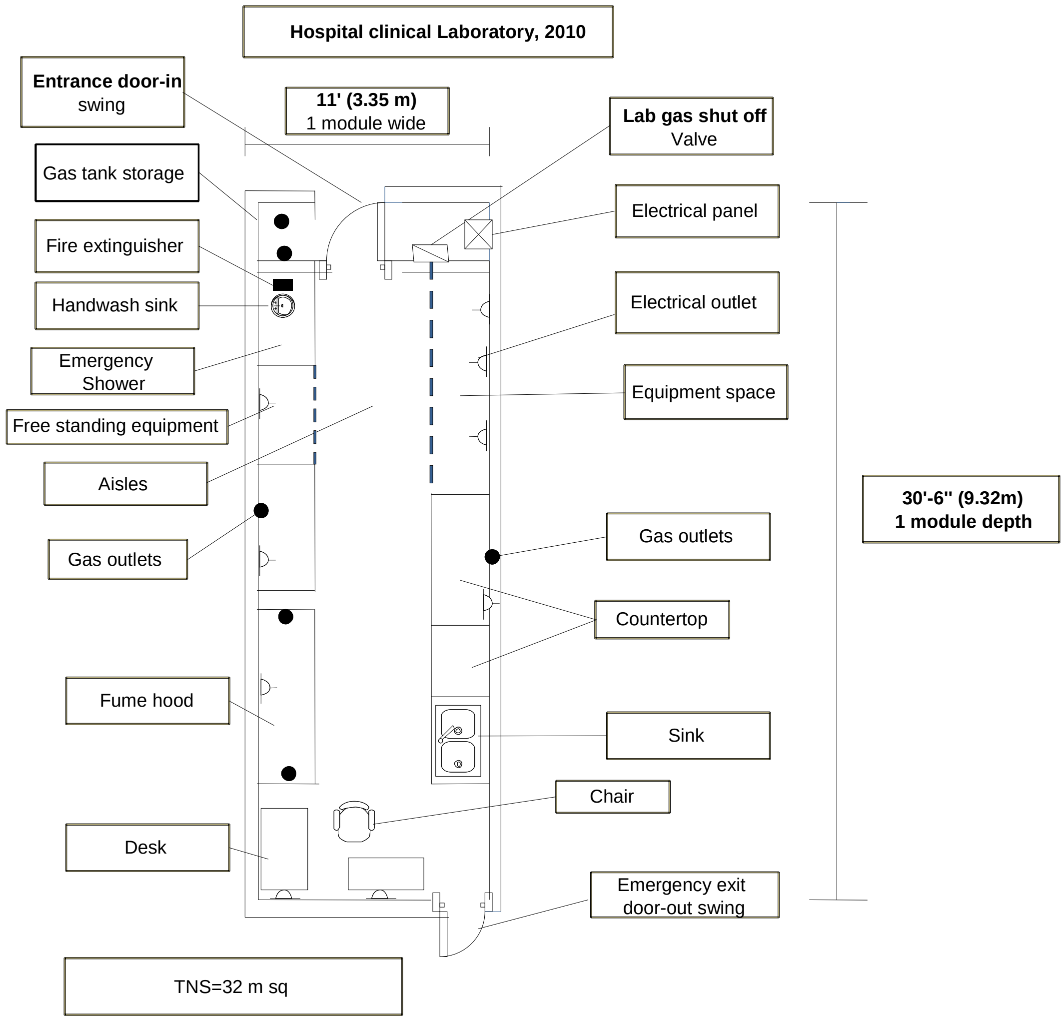

Figure 16 Equipment and utility plan: Single module laboratory, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

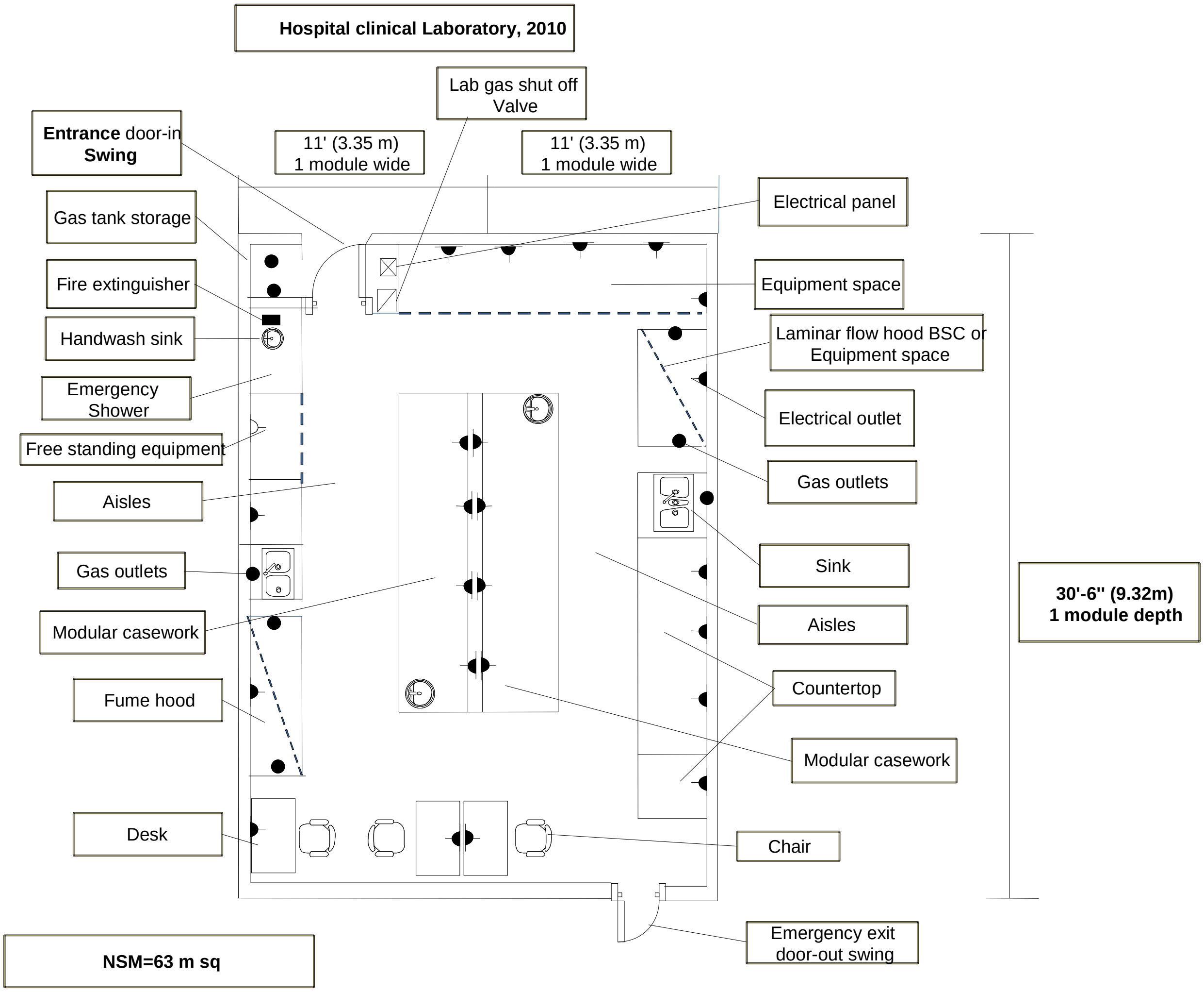

Figure 17 Equipment and utility plan: Double module laboratory, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

Table 7 Current recommended Illuninance categories for clinical laboratory, Nov 2011-Feb 2011, Addis Ababa, Ethiopia.

Area activity Laboratories	Illuninance category	Ranges of Illuninance-LUx	Foot candles
Specimen collection	E	500-750-1000	50-75-100
Chemistry room	E	1000-1500-2000	100-150-200
Bacteriology rooms	E	500-750-1000	50-75-100
General Reading culture plates	F	1000-1500-2000	100-150-200
Hematology	E	500-750-1000	50-75-100
Lobby	C	100-150-200	10-15-20
Locker rooms	C	100-150-200	10-15-20
Toilets	C	100-150-200	10-15-20
Waiting area General	C	100-150-200	10-15-20
Local for reading	D	200-300-500	20-30-50
Corridors	E	500-750-1000	50-75-100

How do the laboratory Space determine during the planning and programming design phase?

Allocation and organization of space are among the most controversial issues in the laboratory design. Laboratory space is currently determined based on the feature of the laboratory itself. These would include the laboratory equipment, work areas, plumbing fixtures, aisles and code clearance. The necessary space for a particular laboratory requires an understanding of all its functions.

During preparation of the planning and program statement and the current space needs assessment were serve as the foundation for predicating future space need. Customized space needs predications were made based on change in total equipment/instrumentation size and bench top workspace.

Current space needs calculation

By measuring all current chemistry equipments in Black Lion Hospital Laboratory and using formula below possible to calculate the current space and predicate for future. Therefore, based on the current space need of chemistry laboratory the total net assignable square meter (TNS) was 137 out of total gross area of 149m2. The calculation was done after measuring equipment on floor mounted and on bench and finally providing the desire aisle width between caseworks.

The formula was used below:

$$BWS = Length \times Width$$

$$= (\sum AE + \sum CWS) \times (CD + IW)$$

Calculate FMI

$$TNS = BWS + FMI$$

Where, BWS=Bench working space

AE=Linear footage of all analysis equipment

CWS= Clear working space

CD= Sum of counter depth

IW= Desired aisle width

FMI= Actual square forage of floor-mounted items

TNS= Total net space

Laboratory lean design method

Since the chemistry laboratory workflow were studied in detail such as value and non-value added activities, wasted space, employing walk path, equipment, supplies and materials were already identified and these favoured a chance to develop the new layout of chemistry laboratory. Therefore, for lean laboratory design this laboratory was taken as a model to develop the net square space since it was examined in detail comparatively from other section of laboratory. The focus of the lean in the chemistry laboratory deign was to add value, remove wasteful practices with technologists, reagent/samples, and equipment and create a testing process toward single-piece flow.

Based on ideal modeling of layout of chemistry laboratory by lean principle the total net assignable square were reduce by 46.4% from current total net assignable square meter. The current net assignable space of chemistry laboratory was 137 and after lean modeling it was reduce into 73.5 net Square meter (Figure 16). Beside that together with lean design and various ergonomics workstation were considered and included before the design laboratory initiative by selecting and specifying the highly flexible standing and seating countertop and casework and also highly adjustable laboratory chair were used in developing the ideal layout of laboratory since always before actual construction of building computer layout calculation was important.

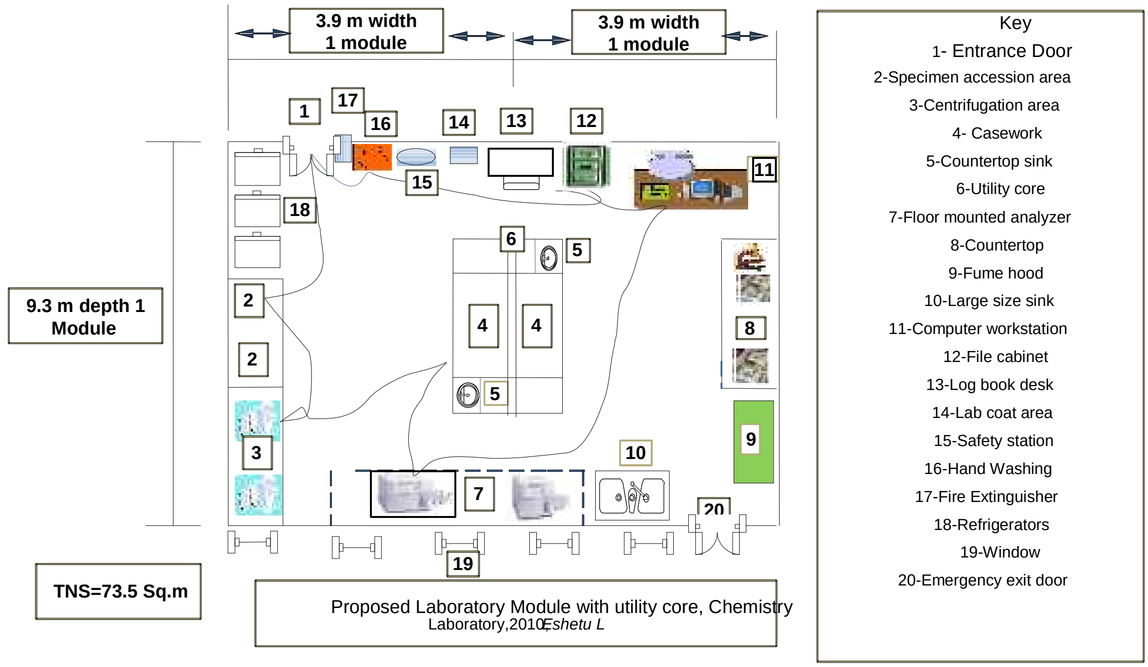

Figure 18 An example of lean design chemistry laboratory layout for Blank Lion Hospital, **Nov** 2011-Feb 2011, Addis Ababa, Ethiopia.

Annex 5 Ergonomics Personnel Questionnaire-Self Administered

Sr. No	Items
101	Age in years_____ ☐
	Gender Female ☐ Male ☐
102	Time of employment in the institution ☐
	Marital status Single ☐ Married ☐ Separated/widowed ☐
103	Educational level Certificate ☐ Master ☐ Diploma ☐ PHD ☐ Degree ☐
104	Daily work-shift 6h ☐ 8h ☐ 12h ☐
105	Previous performance of the same activity in a different institution No ☐ Yes ☐
106	Has a second job eg. part time No ☐ Yes ☐
107	Overtime work No ☐ Yes ☐
108	Previous diagnosis of rheumatic or bond disease No ☐ Yes ☐
109	Previous diagnosis of work-related musculoskeletal disorder No ☐ Yes ☐
110	Practices physical activity regularly No ☐ Yes ☐
111	Does housework daily No ☐ Yes ☐
112	Spent time taking care of children <5 years old No ☐

	Yes ☐
113	Visiting a doctor for work-related musculoskeletal disorder No ☐ Yes ☐
114	Restricted working days and lost working days No ☐ Yes ☐
112	Is the main workstation good enough? No ☐ Yes ☐
113	Average standing time per day No ☐ Yes ☐
114	Average sitting time per day No ☐ Yes ☐
115	Rest pause after every working No ☐ Yes ☐
116	How many days/month/year working in the present workplace =__/__/__
117	Do you heard about laboratory ergonomics before? No ☐ Yes ☐
118	If yes, what is laboratory ergonomics? ☐
119	Do you know WRMD before? No ☐ Yes ☐
120	If yes, did you report to lab director or immediate boss? No ☐ Yes ☐
121	Did you try the work to fit to you or not? No ☐ Yes ☐

Annex 6 Lab Manager Knowledge of Ergonomics Questionnaire-Self Administered

Sr. No	Items	Comments
201	What is laboratory ergonomics? ☐	
202	What is your level of knowledge about ergonomics? Low ☐ Average ☐ High ☐	
203	Do you know about ergonomics study or international program? No ☐ Yes ☐	
204	Do you aware of ergonomics principle in the laboratory? No ☐ Yes ☐	
205	Do you know the ergonomics relations between human, equipment, and work process? No ☐ Yes ☐	
206	Do you know poor ergonomics workstation have psychological implication of job satisfaction? No ☐ Yes ☐	
207	Do you know good ergonomics design have increased the quality of laboratory service and productivity? Yes ☐ No ☐	
208	Do you know the correct working posture while lab personnel working different lab procedure or work on different workstation? Yes ☐ No ☐	

Annex 7 Work-Related Musculoskeletal Disorders Questionnaire-Self Administered

Have you at any time during the last 12 months had trouble (such as ache, pain, discomfort, numbness) in:	Have you had trouble during the last days:	During the last 12 months have you been prevented from carrying out normal activities (eg. Job, housework, hobbies) because of this trouble
301 Neck 1-No 2-Yes	**302** Neck 1-No 2-Yes	**303** Neck 1-No 2-Yes
304 Shoulders 1-No Yes 2-in the right shoulder 3-in the left shoulder 4-in both shoulders	**305 Shoulders** 1-No Yes 2-in the right shoulder 3-in the left shoulder 4-in both shoulders	**306 Shoulders (both/either)** 1-No 2-Yes
307 Elbows 1-No Yes 2-in the right elbow 3-in the left elbow 4-in both elbows	**308 Elbows** 1-No Yes 2-in the right elbow 3-in the left elbow 4-in both elbows	**309 Elbows(both/either)** 1-No 2-Yes
310 Wrists/hands 1-No Yes 2-in the right wrist/hand 3-in the left wrist/hand 4-in both wrists/hands	**311 Wrists/hands** 1-No Yes 2-in the right wrist/hand 3-in the left wrist/hand 4-in both wrists/hands	**312 Wrists/hands** 1-No Yes 2-in the right wrist/hand 3-in the left wrist/hand 4-in both wrists/hands
313 Upper back 1-No 2-Yes	**314 Upper back** 1-No 2-Yes	**315 Upper back** 1-No 2-Yes
316 Lower back 1-No 2-Yes	**317 Lower back** 1-No 2-Yes	**318 Lower back** 1-No 2-Yes
319 One or both hips, thighs, buttocks 1-No 2-Yes	**320 Hips, thighs, buttocks** 1-No 2-Yes	**321 Hips, thighs, buttocks** 1-No 2-Yes
322 One or both knees 1-No 2-Yes	**323 Knees** 1-No 2-Yes	**324 Knees** 1-No 2-Yes
325 One or both ankles/feet 1-No 2-Yes	**326 One or both ankles/feet** 1-No 2-Yes	**327 One or both ankles/feet** 1-No 2-Yes

Annex 8 Laboratory Design Checklist-Observational

Serial No	Items	Yes	No	NA	Remarks
	A. Space				
401	Calculate each laboratory space in Sq.m and percentage of each from total	☐	☐	☐	
402	Do the laboratories have addition rooms like mini conference room, classrooms and teaching lab, office, warehouse?	☐	☐	☐	
403	Is the laboratory and non-laboratory activities are segregate?	☐	☐	☐	
404	Is the lab has a separate office spaces for lab employees?	☐	☐	☐	
405	Is the lab has a separate corridor in accessing lab personnel by public access to that of lab corridor?	☐	☐	☐	
406	Do labs have adjacent support spaces for the purpose of storage and/or the consumption of food, drinks, tobacco products, and the application of cosmetics?	☐	☐	☐	
407	Does the exits lab space is adequate in terms of work load, No of staff, No equipment?	☐	☐	☐	
408	Calculate functional working space, storage space and support space both for manual or automated method	☐	☐	☐	
409	The minimum automated functional working space per person is 81sq.ft of floor space	☐	☐	☐	
410	The minimum manual functional working space per person is 22 sq.ft of floor space	☐	☐	☐	
411	Measure the support space (preanalytical and postanalytical)	☐	☐	☐	
412	Does the lab have unnecessary wall and partition which compromised the space?	☐	☐	☐	
413	Quality of space in terms of no of staff working at time, traffic in and out, no of samples, no of authorized personnel in and out, etc	☐	☐	☐	
414	Does the lab have a separate room for samples receiving so that in managing the lab space	☐	☐	☐	
415	Does the lab have free space for expanding its service next to wall	☐	☐	☐	
416	Does the lab space design is building-locked i.e. surrounded by non-negotiable ,institutionally sensitive area	☐	☐	☐	
417	Does the each sectional of lab space locate near each other since they have some functional relationship	☐	☐	☐	
418	Does the space allocation are similar or difference between lab section since chemistry and hematology section should have larger space relatively	☐	☐	☐	

419	Quality of space in terms of movement of lab personnel, patients and specimen	☐	☐	☐	
420	Does the lab has flexible space for future use by suing flexible casework in the existing lab design	☐	☐	☐	
421	Does the lab equipment have enough space for air circulation around them and proper maintenance	☐	☐	☐	
422	Number and calculate the sq.m of floor space occupied by the sink	☐	☐	☐	
423	Calculate the current total net lab space using the following formula: TNS=BWS+FMI	☐	☐	☐	
424	Does the lab building incorporate adequate additional facilities for food storage/consumption and personal hygiene tasks?	☐	☐	☐	
425	Laboratory areas with autoclaves should have adequate room to allow access to the autoclave and clearance behind it for maintenance	☐	☐	☐	
B. Walls/doors/security					
401	Is the lab completely separated from outside area (i.e must be bound by four walls)?	☐	☐	☐	
402	Is the lab has a lockable doors for security purpose?	☐	☐	☐	
403	Is the lab has a lockable cabinets?	☐	☐	☐	
404	Does the lab doors closed while an experiment is progress?	☐	☐	☐	
405	Is the lab is fireproof construction?	☐	☐	☐	
406	The laboratory shall be completely separated from outside areas (i.e., shall be bound by four walls and a roof or ceiling).	☐	☐	☐	
407	Does the main lab door have at least 1.2m?	☐	☐	☐	
408	Does the interior door have at least 0.91m?	☐	☐	☐	
409	Doors should be fire resistant and fitted with vision panels	☐	☐	☐	
C. Flooring					
401	Is the lab floor made of non-pervious, one piece, and with covings to wall?	☐	☐	☐	
402	Is the lab floor made of tiles and wooden planks?	☐	☐	☐	
403	Is the floor in storage area for corrosive liquids made of liquid tight construction?	☐	☐	☐	
404	Is the lab floor made of non-pervious, one piece, and with covings to wall?	☐	☐	☐	

405	Is the lab floor made of tiles and wooden planks?	☐	☐	☐	
406	Is the lab ceiling height is 10 feet from the floor which is optimal?	☐	☐	☐	
407	Are the labs floors aisles ways maintain a 36 inches clearance and are free of obstructions?	☐	☐	☐	
408	Autoclave drainage should be designed to prevent or minimize flooding and damage to the floor	☐	☐	☐	
D. Sinks					
401	Does the lab have a sink in each section for hand washing?	☐	☐	☐	
402	Does the sink located close to the egress?	☐	☐	☐	
403	Does the lab sink have lips that protect drains from spills?	☐	☐	☐	
404	If yes, measure the inches of sink lips i.e. should be >=0.25 inches	☐	☐	☐	
405	Does sink for BSL-2 lab has a separate hand-washing sink must be available?	☐	☐	☐	
406	Where hazardous, biohazardous, or radioactive materials are used, each laboratory shall contain a sink for hand washing. The sink drain shall be connected either to a retention tank or building plumbing.	☐	☐	☐	
407	Does the sink are highly resistance for acid, alkalis, solvents, salts, abrasive and heat?	☐	☐	☐	
408	Do not install more sinks or cupsinks than are necessary	☐	☐	☐	
409	Sink faucets and hose bibs that are intended for use with attached hoses are provided with back siphon prevention (vacuum break) device	☐	☐	☐	
410	Hand washing sinks for particularly hazardous chemicals or biological agents may need hands free operation	☐	☐	☐	
E. Chemical/waste storage					
401	Does the lab placed chemical storage shelves above lab sinks?	☐	☐	☐	
402	Does the lab have sufficient space or facilities for chemical storage?	☐	☐	☐	
403	If yes, is the storage facility had partitions?	☐	☐	☐	
404	Is the incompatible chemical/gases are separated by their nature?	☐	☐	☐	
405	Do the lab shelves fixed firmly to the wall so that cannot be vibrate out of place?	☐	☐	☐	
406	Cabinets for chemical storage should be of solid, sturdy construction. Hardwood or metal shelving is preferred	☐	☐	☐	

407	Laboratories using corrosive liquids should have ample storage space low to the floor, preferably in low cabinets, such as under fume hoods	☐	☐	☐	
408	Does the chemical storage have enough ventilation system?	☐	☐	☐	
409	Does the hospital have space for handling of waste materials within the building e.g. incineration?	☐	☐	☐	
410	Does the lab have space for variety of waste collection containers?	☐	☐	☐	
411	Does the lab have a cold room for storage of non-hazardous materials?	☐	☐	☐	
	F. Furniture design, location and exit paths				
401	Does lab furniture are sturdy?	☐	☐	☐	
402	Is the work surfaces (bench tops and counters) made of impervious to the chemicals used?	☐	☐	☐	
403	Does the lab use wooden bench top?	☐	☐	☐	
404	Does the lab use fiber glass for bench top?	☐	☐	☐	
405	Does the lab fulfill the minimum aisle clearance of at least 24 inches?	☐	☐	☐	
406	Does the lab fulfill main aisles used for emergency egress of a clearance width of at least 36 inches?	☐	☐	☐	
407	Does the lab shelve installed above 30 cm above shoulder heights or extend arms greater than 30 cm?	☐	☐	☐	
408	Does the lab desks located near to exit ways and comfort for lab personnel in assessing a fresh air?	☐	☐	☐	
409	The countertop should incorporate a lip to prevent run-off onto the floor	☐	☐	☐	
410	Does the lab design clearly show the direction of evacuation plan during emergency?	☐	☐	☐	
411	Does the fire extinguisher access at strategically place and free of obstacle?	☐	☐	☐	
412	Bench work areas should have knee space to allow room for chair near fixed instruments, equipment or for procedures requiring prolonged operation	☐	☐	☐	
413	Work surface should incorporate ergonomics features, such as adjustability, appropriate lighting and equipment layout.	☐	☐	☐	
	G. Lighting				
401	Does the lab area have adequate natural or artificial illumination to ensure sufficient visibility for operational safety?	☐	☐	☐	
402	What is the colour of the work surface?	☐	☐	☐	
403	What is the colour of the adjacent walls and ceiling	☐	☐	☐	

404	Measure the distance from the lighting fixture to the work surface	☐	☐	☐	
405	Are the luminaries mounted perpendicular or diagonal to the work surface?	☐	☐	☐	
406	Are there any cabinets above the work surface that impend the parallel luminaries?	☐	☐	☐	
407	Does the work surface make of dark or off-white matte to reduce the amount of reflection and glare?	☐	☐	☐	
408	What types of luminaries used in each laboratory section?	☐	☐	☐	
409	Does the lab have special lighting system for emergency?	☐	☐	☐	
410	Identify the luminance category in each lab section?	☐	☐	☐	
411	Identify the surface reflectance of ceiling finishes, walls, furniture, equipment, floors	☐	☐	☐	
412	Does the lab exit ways have 30Lux?	☐	☐	☐	
413	How many numbers of light bulbs present in single lab?	☐	☐	☐	
414	Controls for switching the light on and off should be located at entrances and exists to each space?	☐	☐	☐	
415	Fluorescent luminaries should be double switched so that, depending on the level of illumination desired, half of the tubes may be switched on a time.	☐	☐	☐	
H. Cleanability					
401	Does the lab designed in such for easily cleaned?	☐	☐	☐	
402	Does the lab bench tops are seamless one-piece design to prevent contamination?	☐	☐	☐	
403	Does the wall have backsplash when the beach top is abuts to wall?	☐	☐	☐	
404	Does lab wall painted with washable, hard non-porous paints?	☐	☐	☐	
405	Does the lab wall made of wooden or wood finish walls or floor?	☐	☐	☐	
406	Does the lab space between benches, cabinets, and equipment have enough space for cleaning?	☐	☐	☐	
407	Does the lab furniture are made of smooth, non-porous surface?	☐	☐	☐	
I. Electricity					
401	Does the lab have fitted adequate number of electrical outlets which can accommodate electrical current requirement with an additional 20-40% capacity?	☐	☐	☐	

402	Does the lab have circuit breakers which are located outside the lab?	☐	☐	☐	
403	Does the lab have maximum number of electrical outlets to provide to accommodate frequent lab layout changes?	☐	☐	☐	
404	Does the lab electric outlet have ground system?	☐	☐	☐	
405	Does the lab have control system for all electric lines coming into lab controlled with harmonic neutralized-type transformers?	☐	☐	☐	
406	Are wires stretched across the floor that causing a tripping hazard?	☐	☐	☐	
407	Are electrical cords and appliance away from flammable and water (sinks), do they have grounding plugs?	☐	☐	☐	
408	Are extension cords used in the laboratory permanently?	☐	☐	☐	
409	Does the lab get continue power supply through generator if main power is not in place?	☐	☐	☐	
410	Do the electrical outlets have cover plates?	☐	☐	☐	
411	Ground fault circuit interrupters should be installed near sinks and wet areas	☐	☐	☐	
J. Plumbing					
401	Does the lab have auxiliary valves for gas and vacuum lines should be located outside the lab?	☐	☐	☐	
402	Does the lab waste lines separate from other domestic sewage?	☐	☐	☐	
K. Ventilation					
401	Does the lab room have mechanical generate supply air and exhaust air?	☐	☐	☐	
402	Does all lab sections use 100% outside air and exhaust to the outside?	☐	☐	☐	
403	Does the lab have a ventilation rate of 12 to 16 air changes/hour?				
404	Lab ventilation rates should ensure 8-10 air changes per hour minimum for occupied spaces and 6 air changes per hour minimum when unoccupied.	☐	☐	☐	
405	Does airflow direction is from low hazard to high hazard areas?	☐	☐	☐	
406	Does the lab have control system to control the temperature, ventilation rate and room pressurization?	☐	☐	☐	
407	Does the system have provide for control of exhaust system noise (combination of fan-generated noise and air-generated) in the laboratory?	☐	☐	☐	
408	Does the lab noise curve of 55 dBA is generally adequate for standard lab?	☐	☐	☐	

409	When office and lab spaces are connected, airflow should enter via office spaces, and exit via hoods or other exhausts in lab spaces.	☐	☐	☐	
410	Does the built with 100% outside air/exhaust (also called single-pass air)	☐	☐	☐	
411	Laboratory areas should be at a negative pressure relative to corridors	☐	☐	☐	
412	The rule-of-thumb is tair should move from clean to less clean Areas	☐	☐	☐	
413	There should be a thermostat control for each laboratory areas	☐	☐	☐	
L. Emergency eyewash and safety showers					
401	Does the lab have plumed eyewash for all work areas during normal or emergencies?	☐	☐	☐	
402	Do the lab uses drench hoses, sink faucets, or showers for eyewash facilities?	☐	☐	☐	
403	Does a plumed eyewash provided at all work where formaldehyde solution in concentration greater than or equal to 0.1%?				
404	Does the eyewash safety station install within all acid washing areas?	☐	☐	☐	
405	Does the emergency eyewash facilities and deluge showers are accessible located and unobstructed pathway that require no more than 10 seconds?	☐	☐	☐	
406	Does the emergency eyewash/shower are accessible by disabled person within 10 seconds?	☐	☐	☐	
407	Does the emergency eyewash and shower located and identified with a highly visible sign?	☐	☐	☐	
408	Does the eyewash/emergency shower have floor immediately beneath the eyewash/shower?	☐	☐	☐	
409	Does electrical apparatus, telephone, thermostats, or power outlets located with 18 inches of either side of emergency shower/eyewash facility?	☐	☐	☐	
410	Does the emergency shower location have a level surface beneath the shower head?	☐	☐	☐	
411	Do the emergency shower heads provide that not less than 82 inches and not more than 96 inches in height?	☐	☐	☐	
412	Does the spray pattern have a minimum diameter of 20 inches at 60 inches above the surface on which the user stands?	☐	☐	☐	
413	Does emergency shower heads delivering a minimum of 75.7 litters per minute of flushing fluid?	☐	☐	☐	
414	Does the water supply to shower controlled by ball-type shutoff value which is visible and accessible to shower maintenance personnel?	☐	☐	☐	
414	Locate eyewash/safety shower near door. Do not include a floor drain for the shower	☐	☐	☐	

415	Are the eyewash stations kept clean and designed with pop-off covers that must remain in position until the unit is activated?	☐	☐	☐	
	M. Flammable liquid storage				
401	Does the lab have one or more flammable liquid storage cabinets?	☐	☐	☐	
402	Does the flammable liquid storage cabinets are conspicuously labelled in red letters on contrasting background “FLAMMABLE-KEEP FIRE AWAY”?	☐	☐	☐	
403	Does the lab design different storage for each hazard when flammable or combustible liquids present multiple hazards?	☐	☐	☐	
404	Does the flammable liquid storage cabinet design the following points: minimum wall thickness of 0.044 inches, double walled construction with a minimum air of 1-1/2 inches between the walls, tight-fitting joints, welded or riveted?	☐	☐	☐	
405	Does cabinet doors are self-closing and self-latching?	☐	☐	☐	
406	Does flammable liquid storage cabinets required vents when only significant odor or vapour?	☐	☐	☐	
407	Does the flammable liquid storage room/cabinets attached with venting duct?	☐	☐	☐	
408	Does the liquid storage cabinets located near exit doorways, stairways, or in a location that would impede egress?	☐	☐	☐	
409	Does the flammable liquid storage cabinets are wall mounted?	☐	☐	☐	
410	Does the lab design ensure that flammable liquid storage cabinets located near an open flame or other ignition source?	☐	☐	☐	
411	Are corrosive and flammable chemicals stored below eye level?	☐	☐	☐	
	N. Window				
401	Does the lab have insect screens if the window is open?	☐	☐	☐	
402	Do the labs have enough open windows for natural lighting (for energy saving system)?	☐	☐	☐	
403	Windows should be sealable and fitted with blinds	☐	☐	☐	
	O. Casework				
401	Does the casework is built-in building?	☐	☐	☐	
402	Does the casework can be removing, relocated, and reused in other areas of a building?	☐	☐	☐	
403	How many caseworks are exists in the lab?	☐	☐	☐	
404	Does the casework have gas, vacuum, air outlets?	☐	☐	☐	

405	Does the drawers are work properly?	☐	☐	☐	
406	Does the lab doors are wider than the casework?	☐	☐	☐	
407	Does the casework and chair are high quality adjustable?	☐	☐	☐	
408	Measure typical desks and stand-up work benches from the floor for adult man and women	☐	☐	☐	
409	Is the casework is fixed or modular	☐	☐	☐	
410	Is the casework made of steel, wood or plastic laminate?	☐	☐	☐	
411	Does the casework system attach the countertops, drawers, and storage cabinets?	☐	☐	☐	
412	Does the casework support the wiring and electrical connections?	☐	☐	☐	
413	Does the use combine fixed casework, modular casework, and mobile furniture?	☐	☐	☐	
P. Countertops					
401	Does the bench material have load-bearing properties and resistance to heat, acid/alkali, organic solvents, staining property?	☐	☐	☐	
402	Does the countertop made of wood core, synthetic stone, or metal?	☐	☐	☐	
403	Does the countertop edge rounding or not? Specially for plastic laminate	☐	☐	☐	
404	Are the heights of the sit-down workbench and desk meets 30 inches (76.2cm)?	☐	☐	☐	
405	Is the height of the stand-up workbench meet 36 inches (91.4 cm)	☐	☐	☐	
406	The computer keyboard height is generally 26 to 27 inches	☐	☐	☐	
407	Knee clearance under sit-down work area 28 inches (71.1cm)	☐	☐	☐	
Q. Water					
401	Water used in laboratory is of two basic types: potable (drinkable) water and treated (purified) water	☐	☐	☐	
402	Does the lab have water distillation room?	☐	☐	☐	
403	To protect the potable water system from contamination from waste or "purified" water systems, backflow-preventing valves must be installed	☐	☐	☐	
404	Lab staff members frequently discharge acids, alkali, or organic solvents into the drains, the drain pipes should be constructed of non-reactive materials, such as plastic or glass	☐	☐	☐	

Annex 9 Laboratory Ergonomic Checklist-Observational

	Yes	No	Change/Modification	Comments
A. Standing Bench				
501. Is the height of the bench appropriate for the work performed? a. Work can be positioned close to elbow height (~ 36-40”) b. Work can be performed with shoulders relaxed	☐	☐	☐ Adjustable height benches ☐ Adjustable chair ☐ Temporary standing platforms ☐ Move the task to a seated bench with adjustable chair	
502. Are primary work tools and supplies located within arm’s reach (4-18”) from table edge?	☐	☐	☐ Reposition tools and supplies within 18” distance ☐ Provide tool organizers, turntable workstations, turntables, storage bins, pipette holders and carousels	
503. Is there knee and foot clearance when completing standing tasks in front of the bench? a. 4” deep knee clearance b. 4” high and 4”deep foot clearance	☐	☐	☐ Work at open bench cut outs ☐ Remove supplies and equipment from bench cut out areas ☐ Modify bench surface with clamp on cut out extensions to increase knee and foot clearance	
504. Is a foot rail or prop available (6” from floor)	☐	☐	☐ Install rails or foot props ☐ Use footrest ☐ If bench has undersurface cabinet, open or remove door and place foot on lower shelf	
505. Are there floor mats in areas where prolonged standing tasks are completed?	☐	☐	☐ Provide floor mats ☐ Use cushioned shoes and in-soles	
506. Does the bench have rounded or padded edges to reduce contact stress?	☐	☐	☐ Add edge rests and protectors to eliminate sharp edges ☐ Use gel pads on surface to protect elbows ☐ Wear custom padded sleeves under lab coat	
507. Is standing bench available for tasks requiring frequent movement between workstations?	☐	☐	☐ Redesign work to reduce movement between stations to optimize workflow	
B. Seated Bench				
508. Are bench cutouts available for seated workers? a. Minimum 15” depth b. Minimum 20” width	☐	☐	☐ Redesign benches to provide cut-outs for seated work ☐ Provide sit-stand chairs to improve knee clearance when working ☐ Clear out cutouts if cluttered with supplies or equipment	

509. Are work items within close reach? a. Maximum 24”	☐	☐	☐ Reposition tools and supplies within 24” distance ☐ Provide tool organizers, turntable workstations, turntables, storage bins, pipette holders and carousels	
509. Is seated bench available for tasks requiring precision and close inspection?	☐	☐	☐ Provide arm supports for stability if not available ☐ Provide sit-stand stools ☐ Provide adjustable work platforms to position work at optimal height	
C. Laboratory Chairs				
510. Can the laboratory chairs be adjusted to accommodate all workers? a. Seat height appropriate for work at height of benches? b. Feet supported on floor, ring or footrest?	☐	☐	☐ Provide chairs with adjustable height and angle seats and backrests ☐ Provide chairs with foot rings ☐ Provide footrests	
511. Are armrests adjustable or removable if they interfere with work?	☐	☐	☐ Adjust armrests to provide support with shoulders in neutral postures ☐ Remove armrests	
512. Are appropriate footrests or footrings provided?	☐	☐	☐ Provide industrial footrest ☐ Install foot ring on chair ☐ Install rail or platform	
513. Do employees know how to adjust chairs?	☐	☐	☐ Train employees to adjust chair	
D. Microscopes				

514. Can employees view the eyepiece with neutral neck, shoulder and back postures? (Neck flexion < 25°, shoulders relaxed, back upright and supported by chair?)	☐	☐	☐ Reposition microscope
			    ☐ Adjust height
			    ☐ Adjust angle
			☐ Reposition worker
			    ☐ Adjust posture
			    ☐ Adjust seat height
			    ☐ Adjust seat angle
			☐ use arm support/pad	

515. Is the microscope positioned within easy reach of the worker? (Generally close to the edge of the workbench)	☐	☐	☐ Reposition microscope
			    ☐ Move closer to front of counter
			☐ Reposition worker
			    ☐ Adjust posture
			    ☐ Sit closer to bench	

516. Can the microscope be positioned to promote neutral head, neck, shoulders and arm postures when used?	☐	☐	☐ Reposition microscope
			☐ Use microscope adapters
			    ☐ Positioning plate
			    ☐ Ergo adapter
			    ☐ Scopease
			    ☐ Optical wedge
			    ☐ Extended eyetube
			    ☐ Eyepiece adapter
			☐ Use video system	

517. Are arms supported by worksurface, chair armrests, or pads for prolonged work?	☐	☐	☐ Use arm supports ☐ Use pads ☐ Adjust armrests ☐ Adjust worker position	
518. Can the worker use the microscope controls with arms supported and relaxed?	☐	☐	☐ Reposition microscope ☐ Use microscope adapters ☐ Use arm supports/pads ☐ Adjust armrests ☐ Adjust worker position	
519. Is there sufficient legroom and foot support when using the microscope?	☐	☐	☐ Work at bench cut-out ☐ Clear cut-out of clutter ☐ Provide footrest ☐ Provide foot ring	
520. Are microscope work breaks provided?	☐	☐	☐ Institute work rotation ☐ Institute work breaks	
E. Pipettes				
521. Is manual pipette use limited to less than 4 hours per day?	☐	☐	☐ Institute work rotation ☐ Institute work breaks ☐ Consider use of alternative pipettes	

522. If pipette use is more than 4 hours per day, are multi-channel, electronic or latch mode pipettes available?	☐	☐	☐ Evaluate use of alternative pipettes
			    ☐ Electronic
			    ☐ Latch-mode
			    ☐ Multi-channel	

523. Have employees been trained to select appropriate pipettes for pipetting task?	☐	☐	☐ Employee training	
524. Are racks, trays, beakers and supplies available and placed within easy reach?	☐	☐	☐ Provide racks and trays ☐ Position supplies within close reach ☐ Use pipette racks and organizers	
525. Are vials, tubes and receptacles as low profile as possible?	☐	☐	☐ Provide short beakers and vials ☐ Provide short tips and tubes ☐ provide short/angled waste receptacles	

526. Do workers pipette with shoulders relaxed, and arms and wrists in neutral postures?	☐	☐	☐ Employee posture training ☐ Adjust work position ☐ Adjust workstation set-up	
527. Are rest breaks provided?	☐	☐	☐ provide work breaks or work rotation	
F. Micromanipulation				
528. If forceps are used for prolonged periods, are locking mechanisms, o-rings or other adapted aides used to reduce prolonged or static pinch forces?	☐	☐	☐ Provide adapted tweezers/forceps ☐ O-rings ☐ Pads/foam grips ☐ Self-closing ☐ Low force tools ☐ Alternate fingers/hands	
529. Are vials easy to cap and thread?	☐	☐	☐ Provide easy opening caps ☐ Provide vials with minimal number of threads	
530. Are cap openers available?	☐	☐	☐ Provide decapping tools	
531. Are clamps and holders available to support test tubes and other materials that must be help for prolonged periods?	☐	☐	☐ Provide vial clamps ☐ Provide racks, holders, shelves, or organizers	
G. Miscellaneous				
532. Is there adequate and appropropriate storage for supplies? a. Is sufficient space available for supplies? b. Are heavy bottles and boxes stored on low shelves?	☐	☐	☐ Provide storage for supplies ☐ Place heavy items on shelves between knees and chest level	
533. Are jars easy to open or are jar openers available?	☐	☐	☐ Provide jar openers	
534. Are temporary platforms available for tasks that require elevting arms above chest level for prolonged periods?	☐	☐	☐ Consider standing platforms or elevated work areas (Consider safety issues and reduce fall risks before using)	
535. Are there adequate bins and racks for frequently used items?	☐	☐	☐ Provide bins, racks and shelves for frequently used items	

H. Cumputer workstation				
546 . Is the top of your monitor parallel to your eyes?	☐	☐	☐	
547. Is your monitor screen placed in such a way that light from windows and overhead lighting does not cause glare? If not, are glare screens used?	☐	☐	☐	
548. Are you able to operate the pointing device without extended, long duration, or repetitive reaching?	☐	☐	☐	
549. Is your pointing device (e.g. mouse) on the same plane as the keyboard and in a comfortable position?	☐	☐	☐	
550. Is the seat height adjustable so that the entire sole of your foot rests on the floor or footrest, and the back of the knee is slightly higher than the seat of the chair?	☐	☐	☐	
551. Does your chair have five or more legs?	☐	☐	☐	
552. Are the lighting levels in your workspace comfortable?	☐	☐	☐	

Annex 10 Laboratory Workflow Checklist-Observational

Sr. No	Items	Yes	No	NA	Comments
General Consideration					
601	Do the laboratory open its service 30 minutes or one hour before actual office hour to reduce the number of patient in the morning				
602	If yes, do the laboratories add more staff in the morning that afternoon?				
603	Do those patients needing X (e.g. urine) testing have their specimens collected in the interval b/n arrival and blood draws if they had?				
604	Do the lab have flow coordinator role that responsible for escorting patients from the waiting area to the drawing stations?				
605	Is the laboratory is providing special service?				
606	Is all laboratory service located in one area?				
607	Are parts of laboratories located in separated place?				
608	Is it a core laboratory design or departmentalized?				
609	Is the lab equipment is modern?				
610	Is it fully automated or is it semi-automated?				
611	Is it a batch analyzer or is it a discrete analyzer?				
612	Is the test performed manually or automated?				
613	How many and what type of employees are needed to do the work in each lab sections?				
614	Will the work come one or two times during the day?				
615	Who delivers the specimens?				
616	Is the test to be performed routinely or is it stat?				
617	Is the lab service deliver patient result on time?				
618	Is the staff allocated rightly to the job assigned?				
619	Is the workload is high per day?				
620	Does the lab need new equipments and addition staffing?				
Pre-analytical phase					
621	Where are the specimens collected?				
622	Who collects the specimens?				
623	How are the specimens transported to the lab?				
624	Are there guidelines for collection, labeling, preservation and handling?				
625	Is there a unique identification for each patient specimen?				
626	What procedures are in place to prevent mislabeling or mishandling?				
627	How are the laboratory specimens received?				
628	Are there guidelines for acceptation and rejection of specimens?				
629	How is a rejected specimen handled?				
630	What are the acceptance criteria for specimens?				
631	How are the specimens processed?				

632	How are specimens checked for correct labeling?	☐ ☐ ☐	
633	How specimens are stored pending testing?	☐ ☐ ☐	
634	Are specimens stored in a manner that assures specimen integrity prior to testing?	☐ ☐ ☐	
635	How is testing ordered?	☐ ☐ ☐	
636	Is there a pending work list for the technologist to follow?	☐ ☐ ☐	
637	What checks are used to make sure a test request is not missed?	☐ ☐ ☐	
638	What checks are used to assure an ordered test was performed?	☐ ☐ ☐	
639	Is there a policy for retaining tested specimens?	☐ ☐ ☐	
640	What system is used to store and retrieve frozen specimens?	☐ ☐ ☐	
641	Are the SOPs complicated or difficult to understand easily?	☐ ☐ ☐	
642	Are samples are collected properly according to SOP?	☐ ☐ ☐	
643	Is well written manuals available?	☐ ☐ ☐	
644	Is the manual and SOPs are visible and easy traceable for operator?	☐ ☐ ☐	
645	Does the sample collector had been got any formal training?	☐ ☐ ☐	
646	Does the lab collect specimen off site or outside of hospital?	☐ ☐ ☐	
647	How is the courier schedule?	☐ ☐ ☐	
648	Does the lab use computer or manual system to log/document specimen information?	☐ ☐ ☐	
649	Does the lab have accepted or reject criteria?	☐ ☐ ☐	
650	Does the specimen stand longer time on receiving area?	☐ ☐ ☐	
Analytical phases			
651	Will the test done manually or automated?	☐ ☐ ☐	
652	What equipment the lab used, old or modern new one?	☐ ☐ ☐	
653	Are manual or SOP are available?	☐ ☐ ☐	
654	Do the operators follow the SOP correctly?	☐ ☐ ☐	
655	Do the operators perform the test without the SOP?	☐ ☐ ☐	
Post analytical phase			
656	Do the operators interpret the results based on SOP?	☐ ☐ ☐	
657	Is the lab results recorded on computer or manual log?	☐ ☐ ☐	
658	Is LIS is placed in the lab process?	☐ ☐ ☐	
659	Is confidentiality of patient results scurried?	☐ ☐ ☐	
660	Is there any rule or guideline available in use of patient result by lab staff or other?	☐ ☐ ☐	
661	Is there any clear SOP on how the patient result going from start into end?	☐ ☐ ☐	
662	What type of reporting media the lab used while providing the results to end user?	☐ ☐ ☐	
663	Does the lab use separate result sheet and attached it the prescription form or the operator write the result only by handwriting?	☐ ☐ ☐	
664	Is the operator handwriting is legible?	☐ ☐ ☐	
665	Is there any backup mechanism of patient results?	☐ ☐ ☐	

Annex 11 Information sheet (English Version)

Addis Ababa University, Medical Faculty, School of Medical Laboratory Sciences

INFORMATION SHEET

Questionnaire for data collection on the laboratory design, ergonomics workstation in relationship to work-related disorders and workflow of laboratory.

Identification: Type of facility________________ Name of facility____________________

Institution code_________________

Address: Kifle Ketema___________________ Kebele____________

Telephone_________________

Hello, how are you? My name is…………………………………………… I am currently a student of Addis Ababa University, School of Medical laboratory Sciences going to conduct a survey. I would like to interview you few questions about laboratory design, ergonomics workstation in relationship to work-related disorders and workflow of laboratory in this hospital. The objectives of the study are to evaluate the laboratory design, ergonomic workstation and workflow in clinical laboratory in Addis Ababa, Ethiopia. Your cooperation and willingness for interview will be very helpful in identifying the problems related to the issue. Your name will not be written in the form and I assure you all the information you give will be kept strictly confidential. Your participation is voluntary and you are not obliged to answer any questions that you do not want to answer. If you are not comfortable with the interview, please feel free to stop any time you like. Do I have your permission to continue?

If yes, continue to the next page for the interview.

If no, continue to the next patient.

For any information you can contact:

Mr. Eshetu Lemma ***E-mail:*** eshetulema@yahoo.com ***Tel: +251 911635684***

Institutional Review Board (IRB): ***E-mail:*** aaumfirb@yahoo.com ***Tel: 011-553-87-34***

Fax +251-1-1-513099

Annex 12 Consent Form (English Version)

Addis Ababa University, Medical Faculty, School of Medical Laboratory Sciences

CONSENT FORM

I have read the information sheet above and clearly understood the purpose and anticipated benefit of the research. I hereby need to assure with my signature below that I, without any coercion or forceful act by the research team, have decided to voluntarily participate in the study to contribute my part in the effort being made for the laboratory design, ergonomics workstation in relationship to work-related disorders and workflow of laboratory .

Signature ___________

Date___________

Interviewer's name____________________________________

Signature__________________

Date of interview__________________Time started____________ Time finished__________

Supervisor's Name_____________________ Signature_____________________

I thank you for your cooperation

For any information you can contact:

Mr. Eshetu Lemma E-mail: eshetulema@yahoo.com ***Tel: +251 911635684***

Institutional Review Board (IRB): E-mail: aaumfirb@yahoo.com ***Tel: 011-553-87-34***

Fax +251-1-1-513099

Annex 13 Information Sheet: Amharic Version

Addis Ababa University, Medical Faculty, School of Medical Laboratory Sciences

INFORMATION SHEET

ይህ መጠይቅ በአዲስ አበባ ከተማ በመንግስት ጤና ድርጅቶች ውስጥ በሚሰጡ የፀረ-ኤች አይ.ቪ/ኤ.ድስ ህክምና መቆጣጠሪያ የላብራቶሪ አገልግሎት ዙሪያ የታካሚዎች እርካታን ደረጃ ለማጥናት የተዘጋጀ ነው፡፡

መለያ መረጃ፤ የሆስፒታሉ አይነት ____________________________
የሆስፒታሉ ስም ________________________________
አድራሻ፤ ክፍለ ከተማ ______________ ቀበሌ ______________
የሆስፒታሉ ኮድ ____________________
የሆስፒታሉ ስልክ ቁጥር______________

የቃል ስምምነት፤

እንደምን ነዎት? የኔ ስም ______________________ ይባላል፡፡ እኔ በአዲስ አበባ ዩኒቨርስቲ ህክምና ላብራቶሪ ት/ቤት በጸረ ኤች አይ ቪ/ኤድስ ህክምና መቆጣጠሪያ የላብራቶሪ አገልግሎት ዙሪያ ለሚደረገው ጥናት መረጃ ሰብሳቢ ስሆን፤ አሁን በዚህ አጋጣሚ እርስዎ በሆስፒታሉ ስለሚሰጠው ጸረ ኤች አይ ቪ/ኤድስ ህክምና መቆጣጠሪያ የላብራቶሪ አገልግሎት ጥቂት ጥያቆዎች ለመጠየቅ እወዳለሁ፡፡ የዚህ ጥናት አላማ በዚህ ሆስፒታል በሚሰጠው የጸረ ኤች አይ ቪ/ኤድስ ህክምና መቆጣጠሪያ የላብራቶሪ አገልግሎት ተጠቃሚዎች እርካታ ደረጃ፤ የእርካታውን ደረጃ የሚወስኑ ወሳኝ ጉዳዮች ለይቶ ለማወቅ ሲጠቅም፤ ይህም ሆስፒታሉ ለተጠቃሚው የሚሰጠውን አገልግሎት የበለጠ ለማሻሻል ይጠቅማል፡፡ በዚህ ቃለ መጠይቅ የእርስዎ በፈቃደኝነት መሳተፍ እና ትብብር በዚህ ህክምና ዙሪያ ያሉትን ችግሮች ለማወቅ ከፍተኛ የሆነ ጠቀሜታ አለው፡፡ የእርሶ ስም በዚህ መጠይቅ ላይ አይጠቀስም፡፡ በተጨማሪም የሚሰጡት መረጃ ከተባለለት ጉዳይ ውጪ እንደማይውል እና ሚስጥራዊነቱ የተጠበቀ እደሚሆን አረጋግጣለሁኝ፡፡ በዚህ ጥናት ላይ መሳተፍ በእርሶ ፍቃደኝነት ላይ የተመሰረተ እና መመለስ የማይፈልጉትን ማንኛውም ጥያቄ አለመመለስ ይችላሉ፡፡ በቃለ-መጠይቁ ምቾት ካልተሰማዎት በማንኛውም ጊዜ መጠይቁን ማቋረጥ ይችላሉ፡፡

ወደ መጠይቁ መቀጠል እንድንችል ፈቃደኛ ነዎት?

አዎ ከሆነ - ወደ ሚቀጥለው ገጽ ይሂዱ፤ አይሆንም ከሆነ ...ወደ ሚቀጥለው በሽተኛ ይሂዱ

Annex 14 Consent form: Amharic Version

Addis Ababa University, Medical Faculty, School of Medical Laboratory Sciences

CONSENT FORM

ከላይ የተፃፈውን የመረጃ ቅፅ አንብቤ የጥናቱን አላማና ጥቅም በግልፅ ተረድቻለሁ፡፡ በዚህም መሰረት ያለ ጥናት ቡድኑ አባላት ተፅእኖ በሙሉ ፈቃደኝነት በዚሁ ጥናት በመሳተፍ ለፀረ ኤች አይ ቪ/ኤድስ ህክምና መቆጣጠሪያ የላብራቶሪ አገልግሎት መሻሻል በሚደረገው ጥረት ውስጥ የሚጠበቅብኝን አስተዋፅኦ ለማበርከት መወሰኔን በፊርማዬ አረጋግጣለሁ፡፡

የታካሚው መለያ ቁጥር ________ፊርማ _______ቀን____________________

የመረጃ ሰብሳቢ ሥም _________________________ ፊርማ ____________________

መረጃ የተሰበሰበበት ቀን________የተጀመረበት ሠዓት _______ያለቀበት ሰዓት ________

የተቆጣጣሪ ሥም _______________ፊርማ ____________ቀን__________