Original Article

Installation and implementation of automation and its impact on clinical chemistry laboratory productivity

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Objective: To evaluate the impact of laboratory automation system on productivity with implementation of laboratory automation system in a clinical laboratory

Methodology: This was a cross sectional study conducted at Dow Diagnostic Reference and Research Laboratory during October to December 2019. Laboratory automation system at section of Chemical Pathology was installed. Data were retrieved from laboratory information system from 2011 to 2018 to calculate the annual and average growth rate of workload and test menu. Trends were examined for pattern of workload, full time employee (FTE) and test menu.

Results: Growth rates of workload were 24%, 49%, 41%, 41%, 19%, 45% and 28% for the years 2012, 2013, 2014, 2015, 2016, 2017 and 2018, respectively. Average annual workload growth rate was 35%. Test menu growth rates of 23%, 25%, 10%, 10%, 16%, 4% and 5% were observed for 2012, 2013, 2014, 2015, 2016, 2017 and 2018, respectively. Average annual test menu growth rate was 13.2%. After the adaptation of automation, upward trends were consistently observed in workload and test menu. However; a flat pattern was observed for dedicated FTE.

Conclusion: We found total automation system, as a robust and efficient approach for organizing high workflow. This study demonstrated a productive and dynamic strategy to handle a high workload without any extra labor through laboratory automation. (Rawal Med J 202;46:228-231).

Keywords: Clinical laboratory, automation, workload.

INTRODUCTION

Laboratory testing is directly involved in screening, diagnosis, management and monitoring of abnormal health conditions.[1] Efficient performance of clinical laboratory always produces a profound effect on hospital admission, stay duration and discharge of a patient.[2] Recent advancements in diagnostics technology and modernization of clinical laboratory system have played a commendable role in improvement of health care system.[3,4] Concept of automation in clinical laboratories has led to implementation of total and modular automation systems in clinical laboratories of developed countries.[5-7] Various clinical laboratory standards were proposed by Clinical Laboratory Standards Institute (CLSI) to provide specifications for introducing automation in clinical laboratories. Laboratory automation addresses the issue of turnaround time via increasing the system throughput.[6-8]

Dow Diagnostic Research & Reference Laboratory (DDRRL) is an ISO 15189 accredited, core diagnostic public sector laboratory. The laboratory is providing services to 800-bed tertiary care Dow hospital Karachi. DDRRL has four satellites laboratories and 45 collection units in Karachi and other cities of Sindh and Balochistan. Chemical pathology services are available for 24/7 with an extensive stat and routine test menu. After establishment of core diagnostic laboratory, the patients' influx at DDRRL was rapidly increasing due to cost-effective testing and providing good quality results.

Due to escalating workload and requests for rapid reporting in face of appalling conditions of staff shortage, laboratory automation system (LAS), Accelerator Automated Processing System (APS) by Abbott diagnostics (IL, USA), was selected for Chemical Pathology section in 2013. After completion of successful six years of automation, we aimed to observe the laboratory workload, test menu and FTE. In this study, adaptation process of laboratory automation is described in detail, which might be helpful for other clinical laboratories in

Pakistan for implementation of laboratory automation.

METHODOLOGY

This was a cross sectional study conducted at the section of Chemical Pathology, Department of Pathology, Dow International Medical College from October to December 2019. Chemical Pathology workload, FTE number and test menu were considered as indicators of laboratory productivity. Data of all three measures were retrieved from laboratory information system (LIS) and administration records, for consecutive eight years from January 2011 to December 2018.

Workload was defined as number of tests performed in a given period of time. FTE was defined as number of full time employee working for 56 hours a week. Trends were examined for pattern of workload, FTE and test menu. Annual and average growth rates of workload and test throughput (number of test/hour/year) were examined for pre and post LAS. To observe FTE performance, workload/employee/year was calculated before and after LAS implementation. Annual and average growth rates were calculated for test menu. Years 2011 and 2018 were taken as represented years of before and after period of automation, respectively.

A standard tube barcoding system was designed to implement for tube processing. For tube processing at the level of section, all imperative modules of automation were selected and customized. These modules included middleware (instrument manager), input and output module, refrigerated centrifuges, de-caper, aliquoting module for making daughter tubes and analyzers for clinical chemistry plus immunoassays. Two sets of clinical chemistry (c8000) and immunoassay (i2000) analyzers were installed, based on photometry and chemiluminesence techniques, respectively. A total throughput of this new system was turned out as 1600 and 400 tests per hour. Re-sealer, refrigerated sample retrieval/storage and de-sealer modules were opted for post analytical processing. Automatic belt (track) was customized according to need and ease of our laboratory workflow.

All pre analytical, analytical and post analytical modules were connected by track for sample tube transportation within the designed system. The LIS was bi-directionally interfaced with middle ware of APS. Through special inbuilt archiving and retrieving facility of storage system, sample tubes were easily available without any delay for repeats; recheck with dilutions or additional/reflex testing, if needed. Upon retrieval, requested tubes were de-sealed by de-sealer module and offered to input output module again, for re-analyses. All requests of tests generated from laboratory reception and their results from analyzers were communicated through bi-directional interfacing between LIS and middle ware of APS. Un- interrupted power and water supply systems were ready to making automation system up.

Statistical Analysis: Statistical analysis was performed using SPSS version 19.

RESULTS

Continuous upward trends were observed for workload and test menu. However, pattern was found consistent for FTE numbers during the observed period (mean 21.3±1.5) (Fig. 1). Growth rates for workload were observed as 24%, 49%, 41%, 41%, 19%, 45% and 28% in the years 2012, 2013, 2014, 2015, 2016, 2017 and 2018, respectively. The annual workload was examined for consecutive eight years (Fig. 2). Average annual workload growth rate was found 35% for seven consecutive intervals of years. Number of tests analyzed was improved from 36 tests / hour (2011) to 311 tests / hour (2018), after automation.

Fig 1. Workload and test menu during 2011-18.

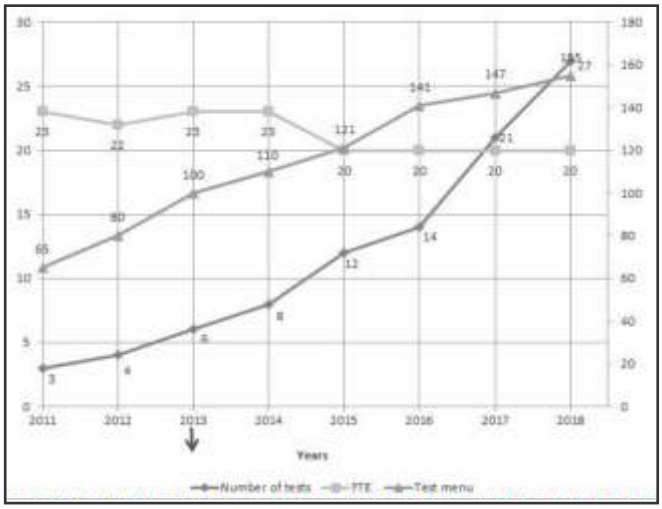
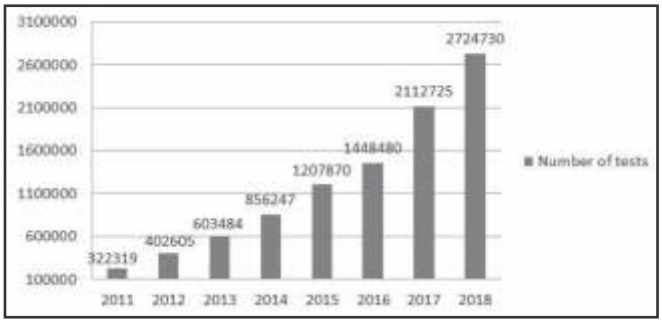


Fig 2. Annual workload of chemical pathology during 2011-18.



Individual FTE work performance improved, from 14013 tests/employee/year in 2011 to 136236 tests/employee/year in 2018. Test menu growth rates were observed as 23%, 25%, 10%, 10%, 16%, 4% and 5% in the years of 2012, 2013, 2014, 2015, 2016, 2017 and 2018, respectively. Average annual test menu growth rate was found 13.2%.

DISCUSSION

Laboratory automation is found a stable platform for dealing with several challenges of modern laboratory diagnostics, including managing workload and quality.[9,10] Laboratory automation offers the integration of multiple testing stations (pre analytical, analytical and post analytical) into a single unit.[11,12] In Pakistan, other than Abbott APS, Roche and Siemens diagnostics are also providing services for LAS. All of these systems are of modular designs and allowing laboratories to select and customize the modules or features as per their needs.[13] Hence, a prior knowledge about requirements of laboratory is crucial before the planning and implementation of automation.[3,12-14] Growth rate assessment of workload, evaluation of system ability to generate number of test results/hour/year and test menu expansion are indicators of laboratory efficiency.[11,15]

Automation is appealing and sophisticated system for the laboratory staff.[11,14] Enhanced performance of laboratory staff was observed in laboratories with automation system.[16] This outstanding performance by same FTE is explained by advanced and robust technology of automation system. APS has inbuilt ability to sense and scan RFID on tube carrier, so it is easy to locate any sample tube within the system.[17] Through this facility, our technologists were able to trace the required sample tube at anytime and anywhere from input to storage module without any delay. Moreover, location of the specific barcoded tube in storage module could be easily found by instrument manager system. Our LAS uptime was found almost 98%. Along with other logistical facilities, system downtime was controlled by the well-trained laboratory staff and biomedical engineers support.

Generating a large number of results for an extensive test menu by using limited resources is one of the key indicators of a successful laboratory.[18,19] On automation system, our laboratory test menu expended from 65 to 155 assays. The annual average growth rate of test menu (13%) is explained by capability of automation system to utilize its analyzer's full assay menu plus flexibility to incorporate other manufacturer's assays.[14] In this study, we observed that after automation laboratory workload was increased and test menu was expanded. FTE were found more productive to generate a high number of quality results. Reduced risk of biohazards and short turnaround time are two other salient features of LAS.[20,22] However, both of them are not addressed in this study due to unavailability of complete data. Further, a comprehensive study is needed to explore more advantages of LAS including cost effectiveness.

CONCLUSION

We found a robust and efficient approach for managing high workflow by implementation of automation. This study demonstrated a productive and realistic approach to handle a high workload without any extra labor by laboratory automation.

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