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CHALLENGES OF AUTOMATION IN A DIAGNOSTIC LABORATORY: EXPERIENCES FROM A TERTIARY HEALTH CENTRE IN A DEVELOPING COUNTRY.

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Abstract:

Diagnostic laboratory forms the backbone of health care systems and is often referred to as the "supreme court of medicine" because it provides timely, accurate information and evidence for patients' management. In sub-Saharan Africa, diagnostic laboratories are among the world's most ill-equipped and poorly resourced facilities despite the huge disease burden it carries. Only about 340 diagnostic laboratories were accredited in Africa out of which 312 (92%) are located in the southern part of Africa. The modern laboratory uses a high degree of automation. Many steps in the analytic process that were previously performed manually can now be performed automatically. This permits the operator to focus on tasks that cannot be readily automated and increases both efficiency and capacity. The analytic process can be divided into three major phases— pre-analytic, analytic, and post-analytic —corresponding to sample management, biochemical analysis, and post-analytical data management respectively.

Substantial improvements have occurred in all three areas in the past decade. The biochemical analytic phase is the most automated, and more research and development efforts are focusing on increasing automation of the pre-analytic and post-analytic processes as well.

INDEX TERMS: CHALLENGES, AUTOMATION, DAIGNOSTIC LABORATORY, EXPERIENCE

INTRODUCTION:

Historically, an increase in the demand for laboratory tests as well as the development of automation for these tests occurred at about a time in the 1950s. This has enhanced diagnostic laboratories to process larger workloads without a comparable increase in the number of staff as well as other logistics.

Automation is not new to many diagnostic laboratories in West Africa. For example, the Department of Chemical Pathology in the premier hospital in Nigeria (UCH, Ibadan) acquired automation capability for general chemistry tests in 1974 and its immunoassay service became fully automated by 2005.

By definition, automation is the replacement of human manipulative effort and facilities in the performance of a given process by mechanical and instrument devices that are regulated by the feedback of information so that an apparatus is self-monitoring or self-adjustment.

Some of the benefits of automation since its application included;

(a) Maximizing laboratory manpower;

(b) Increased productivity - more tests and analysis carried out per person within a given time,

(c) Improved quality of results - minimizes errors; repetitively performed with greater reproducibility,

(d) Minimize variations in results, and reduce the turnaround time,

(e) Reduce wastages (less sample/reagent used per analysis) and less manpower (especially unskilled), and

(f) Better management of the laboratory.

No doubt, automation in a diagnostic laboratory is inevitable and the only way to go especially in the West Africa sub-region because of the following of a high Staff turnover due to migration of experienced staff to better-paid jobs abroad, need to improve outcome quality and reduce turn-around time for efficient service delivery and inter-professional rivalry especially in Nigeria.

However, what is new is the concomitant challenges being faced by the automation process which included;

(a) Frequent changes in technology,

(b) Craze for the acquisition of new technologies for many reasons beyond service delivery,

(c) Invasion of public hospitals by private laboratories under the public-private initiative (PPP) leading to decrease attention being paid to the hospital-based laboratories,

(d) Cost of acquisition and maintenance of automated machines,

(e) The proliferation of manufacturers and suppliers leading to rivalry.

(f) Acquisition cost is often very expensive,

(g) Needed technical expertise and attendant job losses

The federal government of Nigeria and a foreign engineering company started the teaching hospitals equipment modernization project in 2002 and by the 7th of September, 2004 the shipment of the equipment had arrived in the country.

Six months later (by February 2005), about thirty-nine containers of the state of art equipment inclusive of laboratory equipment that arrived at the seaport had not been cleared, talk less of getting to the hospitals or being installed. Blame sharing between the customs, ministry of health, ministry of Finance and the presidency ensued. Nine years later by 2021, with about 180 million dollars expended, various challenges have surfaced in the areas of rehabilitation, design, procurement, supply and installation, reagent and consumables, training of health personnel, and maintenance of the equipment

Most of these challenges faced in Nigeria, are influenced by political goodwill, economic considerations of opportunity costing, and social and cultural factors. Some of these challenges include;

A. Human resources issues: Ownership of automation program by the staff because of the fear of job, inadequately trained personnel to run equipment due to high turnover of experienced staff resulting from migration of staff to better-paid jobs with NGO as well as an inter-professional rivalry. This is what is referred to as 'Brain Circulation Syndrome'

B. Lack of Automation policy: Basic minimum operating standards and national guild-lines on vision/mission, technology type, purchase/lease, duration, management issues sales, and after-sales issues.

C. Infrastructure: Poorly designed laboratory workspace due to left out of users during the design and construction phases leading to difficulty in equipment installation, inappropriate ambient temperature, and variations in the cost modification of the existing laboratory,

D. Erratic supply of pipe-borne water used in the production of distilled or deionized water, and complicated with short hours of electricity supply periods which are too long to be sustained by alternative backup generators or uninterrupted power systems.

D. Equipment: The mismatch between laboratory workload and procured equipment is often a challenge that leads to the installation of outdated unserviceable equipment. This is because the rapid advancement in technology is driven by the first world with equipment having a 3-4 year life cycle with resultant problems in upgrading and replacement when exported to the third world. The major issue is however, the closed versus open systems which result in brake-up in a reagent availability, poor maintenance, and Non-tropicalization.

E. Consumables: The lack of an appropriate memorandum of understanding (MOU) on the regular supply of reagents, consumables, and spare parts which are often manufactured abroad and imported on request leads to delays in procurement

and supply chain. This is always complicated by unstable currency exchange rate and supply chain management 'Middle man syndrome' often leads to increasing cost management.

The issue of lack of adequate storage capacity and space vis-a-vis the quantity needed and the time to make it available is a big challenge that is not usually taken into consideration at the point of acquisition of the machine.

F. Financing: The acquisition of automated analyzers in most developing countries is usually by the government-funded budget releases and with its attendant inadequacies and procurement policies and processes leads to corruption in the process of purchases, moreover, the equipment procurement in many instances, is not user department driven,

The Laboratory Revolving Fund (LRF) initiative which is designed to serve as an independent sustenance mechanism is usually very difficult to operate due to hospital management interferences, lack of transparency, commitment as well as unfriendly policy on internally generated revenue.

G. Information, Communication, and Technology: The absence of a Laboratory Information System as a link to hospital intranet and internet services (LIS) through the Hospital Information System (HIS) has limited the benefit of an automation system. This has in many ways made laboratory management a very difficult and inefficient task.

H. Service delivery: Workload demand from poor sample and specimen management as well as inadequate laboratory requests may affect turnaround time in the result generation. This inturn may contribute to increase costs. The main challenge is the poor commitment and competence of local /foreign partners to sustainability.

A case study review of the challenges above was conducted in a developing country and the challenges' peculiarities may defer from one to another. The outcomes of the review in Nigeria include;

(a) Lack of equipment maintenance due to lack of local expertise despite the initial training program turning the laboratories into "Junk equipment dump sites"

(b) The paucity of funds to complete installations, infrastructural space for equipment, spares parts sourcing and replacement,

(c) Irregular support services like power and water supply as well as management commitment to sustainability,

(d) Alleged non-compliance with terms of contractual agreements, memorandum of understanding (MOU) or memorandum of agreement, (MOA) as the case may be,

(e) Poor and unreliable reagents and consumables supply chain policies,

(f) Lack of commitment, goodwill, and understanding of the laboratory management by the hospital management with the resultant reckless abandonment of the importance of investigative medicine in the effective management of patient care

Recommendations:
The successful deployment and sustainability of laboratory automation in developing countries depend on the following;

- Formation of national as well as harmonized sub-regional laboratory automation policy,
- Involvement of experts and users department especially Pathologists in the laboratory design and construction, purchase/liaise arrangement especially in the areas of reagents, consumable and spare part discussions. This would minimize the influence the 'middle man syndrome' and reduce cost.
- Training and re-training programs for users
- The pooling of resources mechanism by nearby and regional laboratories to address the common challenges of technical expertise, equipment repairs, and supply of spare parts or consumables in order to enjoy the benefits of economy scale. This can be achieved through the establishment of local plants by the manufacturers,
- Dry lease agreement on equipment placement based of various models on private-public partnership arrangements' rather than out-right purchases is the best way to go in view of limited resources,
- Adequate funding through easy access and free operations of the LRF schemes,
- Equipment manufacturers must be made to show more commitment to developing economies.

In conclusion, what is needed in all the countries in the sub-Sahara region especially Nigeria is the dry or wet lease agreement or placement arrangement through the public-private models as opposed to the outright purchase of automated machines.

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The authors declare no competing interest.

Authors' contributions:
Corresponding author: Conception, critical evaluation, review and the script write-up

The second author: Critical evaluation of conception and script review.

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