

# Digitalization of Satellite Laboratory System of Base Hospital Warakapola, Sri Lanka

SMNSM Mallawarachchi<sup>1</sup>, Chandana H Mallawarachchi<sup>2</sup>, Shiranee C Wickramasinghe<sup>3</sup>

## ABSTRACT

**Introduction:** Investigation is a vital component of healthcare. Yet, there are many primary level institutions (PLIs) that do not have the laboratory facilities for their own. Satellite laboratory system (SLS) of Base Hospital Warakapola (BHW) was conceptualized with the aim of offering laboratory facilities for the clients of eight PLIs. The current study aimed to evaluate the impact of digitalization of SLS of BHW.

**Materials and methods:** The process of SLS was extensively studied. The study identified gaps in the process of SLS, BHW (Phase I), implemented the intervention of digitalization of SLS (Phase II), and evaluated the intervention after 3 months (Phase III). Both qualitative and quantitative approaches were used in the study. Patients survey, key informant interviews (KIIs), and desk review of secondary data were the instruments and techniques used. The gaps identified were delay in delivery of reports, errors in transcribing investigation results informed over the phone, poor quality of handwritten reports, and reduced customer satisfaction. The delivery of reports was improved by emailing them to PLIs, which eliminated the requirement of conveying them over the phone. The report was printed at PLIs and issued to patients. The necessary infrastructure facilities to the institutions and training to the staff on use of computers and printers and email were provided.

**Results:** The evaluation of interventions revealed that the availability of reports within 24 hours has improved from 82.19 to 100% significantly reducing the turnaround time of reports. The percentage of reports not collected by patients dropped from 12.92 to 2.87%. The patients' satisfaction was improved about the availability of reports within 24 hours and convenience in cost and time spent significantly. It was noteworthy that both pre- and post-interventional level clients were satisfied about the trustworthiness of SLS. Both the staff of BHW and PLIs expressed their satisfaction with the interventions and improved turnaround time of reports. In conclusion, the project identified the gaps in the process of SLS and was able to overcome them with the interventions. The improvement in the process leads to enhanced efficiency of the SLS.

**Keywords:** Base hospital warakapola, Laboratory investigations, Primary level institutions, Satellite laboratory system.

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## INTRODUCTION

Laboratory investigation is a vital component of healthcare service provision, in the curative as well as preventive sectors. Yet, due to various constraints, some primary level healthcare institutions in Sri Lanka are unable to offer basic laboratory services for the patients they serve. This in turn raises out-of-pocket expenses in healthcare, despite service provision being free of charge to the people.<sup>1</sup>

Base Hospital Warakapola (BHW) Sri Lanka is a secondary care Hospital in Kegalle District, Sri Lanka. The satellite laboratory system (SLS) of BHW offers medical investigation facilities to the clients of eight primary level institutions (PLIs), namely, District Hospital (DH) Beligala, DH Nelundeniya, DH Mahapallegama, DH Narangoda, DH Galapitamada, DH Niyandurupola, DH Algama, and Office of Medical Officer of Health, Warakapola. None of the PLIs had their own laboratory. The SLS intended to support their general medical services as well as screening for non-communicable diseases. The PLIs could send blood and urine samples to laboratory of BHW for selected basic investigations.

An officer from BHW visited each PLI in a scheduled manner and brought the samples from them to BHW and deliver the test results. The transportation was done by a three-wheeler.

When there were no investigation reports to be delivered to a PLI in a day, BHW checked with each PLI if there were any specimens to be picked up before planning the route for that day. Urgent test reports were obtained by PLIs over the phone, and DH Mahapallegama was used to get the reports over the phone routinely.

<sup>1</sup>Department of Health, Ministry of Health, Colombo, Sri Lanka

<sup>2</sup>Department of Medical Parasitology, Medical Research Institution, Sri Lanka

<sup>3</sup>Department of Health, Ministry of Health, Colombo, Sri Lanka

**Corresponding Author:** SMNSM Mallawarachchi, Department of Health, Ministry of Health, Colombo, Sri Lanka, Phone: +94 772325410, e-mail: navodasandamali79@gmail.com

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For quality improvement of clinical laboratories, creating insight among healthcare providers about the issues regarding service delivery while monitoring patient satisfaction are important.<sup>2</sup> The issues in SLS and the relative importance of constraints needed to be evaluated both in the PLIs and in the referral center to ease out the bottlenecks in the process to ensure the efficiency of the system.

Improving access to diagnostics is an essential strategic component of the health service to enhance universal care.<sup>3</sup>

It is recognized that delay in investigation results becomes a rate-limiting step, preventing patients being seen, treated, and discharged timely.<sup>4</sup> Medical officers (MOs) providing healthcare in

resource-limited settings with minimal-to-no laboratory support, are forced to diagnose based only on clinical signs and symptoms which can be non-specific, unreliable, and potentially associated with increased mortality.<sup>5</sup> It can also lead to misuse of drugs, increased costs to the health service, and patient dissatisfaction.<sup>6</sup> Laboratory tests interpreted correctly not only improve the care outcome but also ensure cost containment.<sup>7</sup>

The clinical laboratory has been recognized as an important component to facilitate scientific practice in a standardized hospital.<sup>8</sup> Betterment of the systems within which healthcare providers practice is known to be effective at improving care which is true for laboratory services also.<sup>9</sup> The rapid expansion of the complexity of laboratory testing menus necessitates the patient-oriented nature in services.<sup>8</sup>

With the pressure exerted on clinical laboratories, the importance of innovative strategies to look for solutions, such as rationalization of existing services and cost-effective use of available resources have been highlighted worldwide.<sup>10</sup> Satellite laboratories were expected to overcome constraints identified in centralized laboratory concept including workflow interruption and increased turnaround time.<sup>11</sup>

In a study to evaluate testing options in an academic health center, it was found that satellite laboratories had the highest staff satisfaction scores compared to centralized testing.<sup>12</sup>

The SLS was established for the first time for government health sector in 2006 in Sri Lanka in the district of Badulla with the objective of providing laboratory facilities to resource-poor peripheral hospitals and thereby reducing patient transfers due to non-availability of investigations.<sup>13</sup>

The mission of SLS is to improve both the quality and timeliness of service.<sup>4</sup> In order to place the discipline in a strategically suitable position for the future, it must enhance efficiency.<sup>14</sup>

It has been discussed globally that the future success of any satellite laboratory will depend on the feasibility of integrating that into the medical information system.<sup>15</sup>

It is noteworthy that current study focused on SLS but not on a single satellite laboratory, which is the scope of most internationally published work.

## MATERIALS AND METHODS

The study was conducted in three phases.

- Phase I—Studying the current process of SLS of BHW and identification and analysis of gaps in the process.
- Phase II—Initiation of digitalization of SLS of BHW.
- Phase III—Evaluating the impact by assessing the post-interventional status.

The road map connecting BHW and the eight PLIs were sketched with the use of geographic information system. Average time spent for the three-wheeler to cover the route from BHW to PLIs and back to BHW was calculated by observations conducted at consecutive 5 days.

The patients of PLIs, who were the beneficiaries of SLS were the population for patients' survey. The number of patients selected from each PLI was proportionate to the number of investigations sent in the first quarter of year 2018. If the calculated number of participants was less than 20 from a given PLI, 20 participants were selected from that PLI as a technique of oversampling to compensate for the imbalance in the data.<sup>16</sup> A number of patients interviewed in phases I and III were 412

in each. Convenient sampling was used to recruit the study participants.

Interviewer administered structured questionnaire was used to gather information from beneficiaries of SLS of each PLI to assess their satisfaction regarding the service and the process.

The questionnaire was initially prepared in English after reviewing relevant literatures and the finalized questionnaire was then translated into native languages (Sinhala and Tamil) and retranslated into English to ensure the consistency. The questionnaire was pretested and validated.

A five-point Likert scale was used to gather data on patients' satisfaction on following attributes.

- Availability of reports within a reasonable time.
- Trustworthiness of the service.
- Convenience regarding cost and time spent.

Key informant interviews (KIIs) were carried out to gather data on informants' perception about the gaps in the process of SLS and their suggestions for improvement during phase I. The KIIs were conducted in English or Sinhala as per the choice of informant, according to a KII guides and the questions were open ended in nature. Key informant interviews were conducted with following officers.

- Medical superintendent (MS), BHW.
- Medical officers in-charge (MOIC) of each PLI and Medical Officer of Health, Warakapola.
- Chief Medical Laboratory Technologist (CMLT), BHW.
- Employee of BHW handling transport.
- Sample collecting officers at PLIs.

Desk review of secondary data relevant to the SLS was carried out to gather baseline information required during both the phases I and III namely, the number of tests performed, the timetable of visits of transporter to PLIs, and the number of reports not collected by patients within 1 week once it was made available at the PLI.

Following documents were reviewed to gather information.

- Log notes/running charts of the three-wheeler.
- Duty roster of the driver.
- Records of laboratory of BHW.
- Records at PLIs on delivery of reports.

The qualitative inputs gathered during KIIs were on impression of workload, paperwork, quality of reports, and the ability of the system to convey urgent reports.

At KIIs with MOICs of PLIs, delays in reports, quality of handwriting in reports, instances where reports were not collected by patients and professional judgment on incidence of errors while transcribing the reports communicated over the phone were assessed qualitatively.

Following sections in the process were identified for intervention, namely,

- Improving the communication of reports from BHW to PLIs.
- Improving the report generation, the quality of reports, and the delivery of reports.

The improved method of communication selected was the establishment of delivery of reports through email. To establish the new method, following needs were identified and fulfilled.

- Improvement of infrastructure facilities of BHW and PLIs.

Estimation of the requirements in BHW and PLIs to initiate email-based delivery of reports were carried out and the request

made with a detailed proposal by PI was conveyed to Ministry of Health, Sri Lanka, through Provincial Director of Health Services and funds were mobilized from Directorate of Information. Equipment were procured and distributed among BHW and PLIs.

- Capacity building of relevant staff on email communication.

The staff of the institutions were trained at a workshop conducted by a technical expert from Regional Directorate of Health Services and followed by on sight supervision.

Each PLI nominated at least one officer. They were trained on basic computing skills, using email, and obtaining printouts. Once they successfully completed the training, they were trained to train others in the institution as well.

Data gathered from questionnaires and desk review of records were analyzed from SPSS software and a narrative analysis was performed for KIIs.

In assessing the level of patient satisfaction on selected attributes, very satisfied and satisfied were considered as satisfied and extremely dissatisfied and dissatisfied were considered as dissatisfied. Individuals with neutral responses were excluded.

Z test for proportions was used to test for statistical significance and  $p$  value  $< 0.05$  was considered as level of significance.

## RESULTS

The shortest possible route to cover all PLIs from BHW and back to BHW was estimated to be 67 km of length (Fig. 1) and a round trip to cover the whole route was calculated to be 5 hours by the three-wheeler.

In year 2018, 18,556 investigations were performed by SLS (Table 1). The frequency distribution of investigations sent from PLIs to BHW in year 2018 is depicted in Table 1. Among them, fasting blood sugar (FBS) (31.87%) and total cholesterol (TCL) (29.37%) were the most frequently performed.

Through the qualitative assessment based on KIIs held with the staff of BHW and PLIs, following shortcomings were revealed.

- Excessive paperwork in writing reports and maintaining registers, which was burdensome both to medical laboratory technicians at BHW and staff of PLIs.
- Lack of mechanism to inform urgent results other than conveying over the phone.
- Delays observed in receiving reports. (By norm all the reports were delivered in the day following receipt of samples unless they were communicated over the phone. But the reports of the samples received on Fridays were delivered next Monday.)
- Loss to follow-up patients leaving the reports uncollected at PLIs. (Prolonged turnaround time which was duration from sample collection at PLIs to delivery of the report to PLI were the main reason given by the MOs of PLIs for the issue.)
- Poor quality handwriting in reports.

Improvements pointed out by the MOICs of PLIs and the CMLT of referral laboratory following the implementation of digitalizing the SLS were as follows:

- Chief Medical Laboratory Technologist noted that quality of documentation improved with less paperwork and time saved with the resulted reduction of workload.

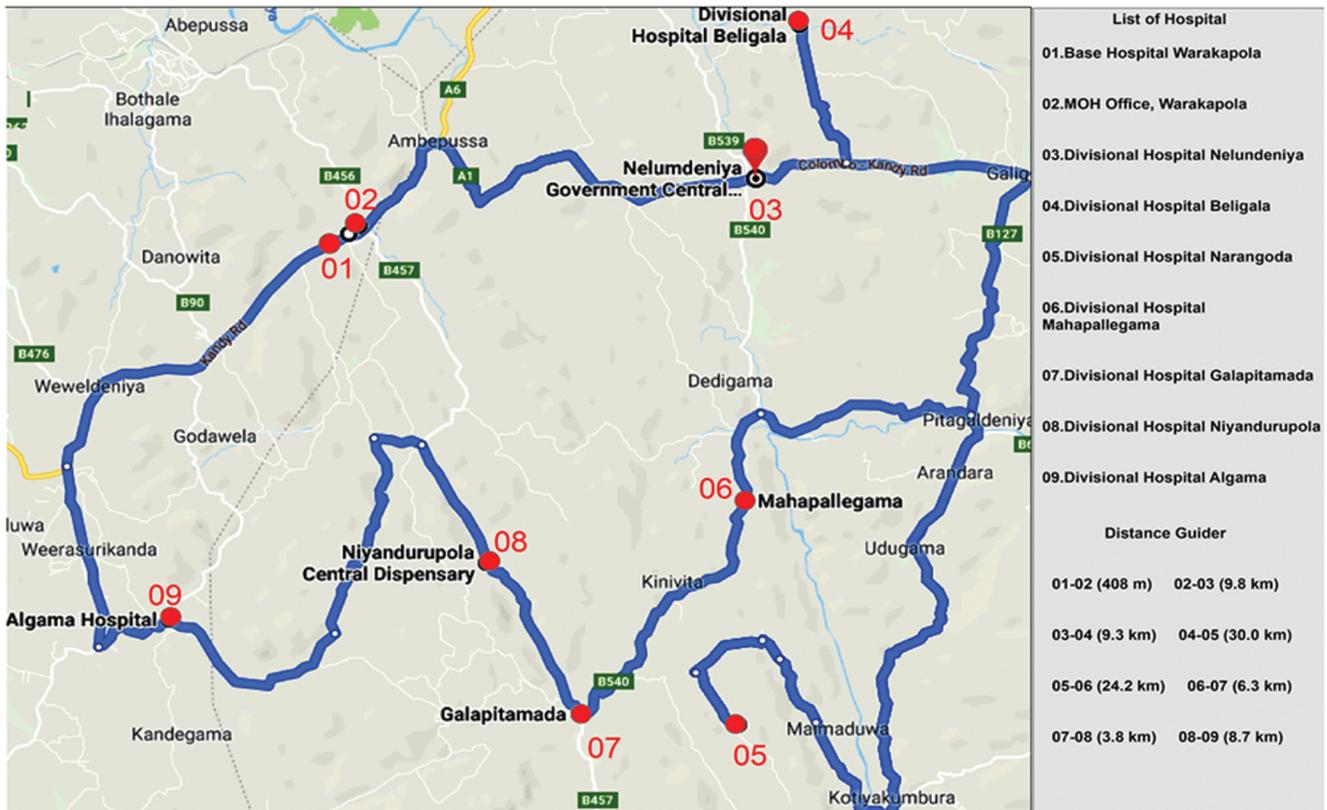


Fig. 1: Road map of SLS BHW

**Table 1:** Frequency distribution of investigations sent from PLIs to BHW in year 2018

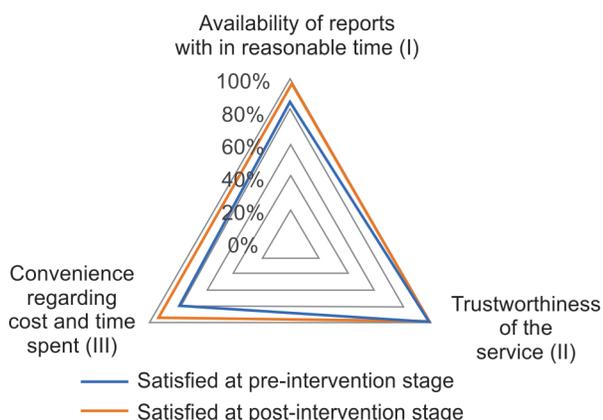
Institution	Investigation				Total
	TCL	FBS	FBC	UFR	
DH Beligala	1,548	1,842	679	188	4,257
DH Nelundeniya	592	456	123	11	1,182
DH Mahapallegama	1,587	2,146	2,348	681	6,762
DH Narangoda	497	470	82	47	1,096
DH Galapitamada	370	123	14	31	538
DH Niyandurupola	658	683	70	38	1,449
DH Algama	198	194	1	3	396
MOH, Warakapola	0	0	1,436	1,440	2,876
Total	5,450	5,914	4,753	2,439	18,556

Source: Records of laboratory, BHW

TCL, total cholesterol; FBS, fasting blood sugar; FBC, full blood count; UFR, urine full report

**Table 2:** Patient satisfaction at pre- and post-intervention stages about selected attributes of the perceived quality of service of SLS

Attribute	Satisfied/not	Satisfied	Dissatisfied	z value	p value
I	Pre-intervention	323 (85.68%)	54 (14.32%)	-4.6592	<0.00001
	Post-intervention	389 (94.88%)	19 (4.66%)		
II	Pre-intervention	385 (98.21%)	7 (1.79%)	-0.3118	0.75656
	Post-intervention	393 (98.50%)	6 (1.50%)		
III	Pre-intervention	304 (79.17%)	80 (20.83%)	-5.0634	<0.00001
	Post-intervention	378 (92.19%)	34 (8.25%)		



**Fig. 2:** Patient satisfaction on selected attributes of the perceived service quality of SLS, BHW; pre- and post-intervention status

- As per the MOICs, the necessity of getting the reports over the phone became zero and the transcription errors were nullified.
- They experienced that the cooperation of patients with the system improved.

The patients' satisfaction on all three attributes regarding SLS had improved and the highest patient satisfaction was observed on trustworthiness of the service (Fig. 2).

The improvement in satisfaction with relevance to availability of reports within 24 hours (I) and convenience regarding cost and time spent (III) was statistically significant at  $p < 0.05$ . But the difference in the satisfaction on trustworthiness of the service (II) was not statistically significant (Table 2).

The percentage of reports not collected by patients in randomly selected 2 months (December 2018 and April 2019) in pre- and

post-intervention stages was 12.92 and 2.87%, respectively. The reduction was statically significant. (The value of z was 8.8994. The value of  $p$  was  $< 0.00001$ ).

It was revealed during KIs, and confirmed with desk review of records of BHW, that delivery of reports to all PLIs took more than 24 hours before the intervention.

Among the reports issued at pre-intervention (December 2018), 17.81% (222/1,246) had been delivered more than 24 hours delayed. But after the intervention (April 2019), all the reports (1,115/1,115) were received by PLI within 24 hours. Turnaround time of reports reduced significantly, and 100% reports reached PLIs within the same day, which was only 82.19% previously (Table 3).

Reports not collected by patients within 1 week after the receipt to the PLIs in randomly selected 2 months during pre- and post-intervention stages were, 12.92% (161/1,246) and 2.87% (32/1,115), respectively. The improvement in the collection of reports by patients was aligned with the betterment of turnaround time of reports.

## DISCUSSION

Improving the efficiency in a laboratory service should be a priority to ensure quality results, a better output and sustained funding, which is possible through ensuring right process, resources, and people management. To improve the efficiency, the current situation should be measured.

Patient satisfaction, which is a critical issue for healthcare providers<sup>17</sup> and vital in assessing deficiencies in health services,<sup>18</sup> was selected as a proxy measure of efficiency of the system, which was assessed through perceived availability of reports within reasonable time, and trustworthiness of the service and convenience regarding cost and time spent.

**Table 3:** Turnaround time of reports pre- and post-interventional stages

Total number of reports	Pre-intervention		Post-intervention		z value	p value
	Reports with turnaround time <24 hours	Total number of reports	Reports with turnaround time <24 hours	Total number of reports		
1,246	1,024	1,151	1,151	-14.808	<0.00001	

The performance, reliability, and acceptability of the tests and their impact on clinical decision-making, and cost-effectiveness have been highlighted in evaluating near patient testing.<sup>19</sup> Similar approach was applied to assess SLS in the current study.

Though assessing cost-effectiveness directly was beyond the scope of current study, the patient satisfaction on convenience of the service regarding time and cost born gave some insight on the aspect.

The average laboratory turnover time considered as a reliable indicator of laboratory performance was used in the current study to assess efficiency.<sup>20</sup> Setting turnover time targets and appraisal of the percentage of tests achieving such, is considered as a method of benchmarking laboratory performance.<sup>21</sup> Lee-Lewandrowski et al. found that increased clinician satisfaction was associated with reduced laboratory turnover time in point-of-care testing satellite laboratory in an emergency department.<sup>22</sup> The current study viewed a similar perspective from patients' angle which showed that the patients' satisfaction was improved with timely availability of reports.

The perception of providers of the service, a recognized factor to determine overall laboratory performance,<sup>23</sup> was assessed in the KILs.

Staff of both laboratory of BHW and PLIs expressed that increased turnaround time of reports and lack of proper mechanism to communicate the reports timely and accurately as negative facts. The PLIs experienced that with high report turnaround time, some reports were left uncollected probably because the patients were either seeking other laboratory's service to get a test done instead of waiting for the SLS report or they went to another healthcare provider who offered laboratory facilities at the point of care.

The positive effect of reduced turnaround time was reflected by the reduction of percentage of reports not collected by patients timely, which was evident in DH Mahapallegama and Beligala. This could be explained with the fact that those hospitals served relatively larger client base and performed full blood count and urine full report, which needs to be delivered sooner. As the other hospitals served less patients, the healthcare provider knew the patients personally and could even contact them when the report was available. It was also noteworthy that such institutions were doing mainly TCL and FBS for clinic patients with few or no other tests, so the burden of prolonged turnaround time was less experienced by them. If a methodology to generate mobile phone alerts to patients, once the report is ready at PLI, the service could be made further efficient even in larger institutions.

The paper-based process and handwritten reports were negatively viewed by all the key players of SLS. Changing the paper-based system to a digitalized process has shown to increase efficiency and improve provider satisfaction in a study performed in USA.<sup>24</sup> The intervention of emailing the reports with the resulting improved turnaround time and ease of workload was appreciated during KILs. The email-based delivery of reports has advantages of data security, clarity, and presentation quality over SMS-based system tried by Jian et al.<sup>25</sup>

Yet, the machine-generated report had to be typed and emailed as the lack of technical feasibility of sharing the same output of the analyzer through email. Further advanced technical support would resolve that constraint.

## CONCLUSION

The SLS of BHW found to have several gaps which prevented it from reaching the fullest possible efficiency, which were successfully addressed by the intervention of digitalization.

Even in resource poor or small-scale healthcare settings, digitalization could be a worthy investment, which ensures better returns in terms of time, money, patients' satisfaction, and health service delivery.

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