International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Costs of Immunoassays at the National Hospital of Sri Lanka – A Laboratory Costing Study

***Dr. Y. Thivakar* [a], *Dr. K. Wickremasinghe* [b]**

[a] *Senior Registrar in Medical Administration, Postgraduate Institute of Medicine, University of Colombo, Colombo-10, Sri Lanka*

[b] *Deputy Director General, National Hospital of Sri Lanka, Colombo-10, Sri Lanka*

DOI: https://doi.org/10.55248/gengpi.4.1123.113141

ABSTRACT

Introduction: Immunoassays are expensive laboratory tests performed to diagnose diseases. It was emphasized to optimize the spending on care services at government hospitals to sustain free healthcare services in Sri Lanka. Optimization of services cannot be achieved without understanding the present through detailed cost analysis. The NHSL has no mechanism to measure the cost incurred for immunoassays.

Objectives: The study's objective was to estimate the per-test cost of immunoassays at the NHSL and compare that with the private sector tariffs.

Method: It was a single-setting bottom-up micro-costing study combined with a top-down approach conducted at NHSL. Reagent costs were considered direct costs and the rest of the expenses were indirect costs.

Results: The per-test direct costs for immunoassays were in the range of SLR.772 to SLR. 6250. The indirect costs per test were estimated to be SLR.114. Indirect costs incurred by; the remuneration of human resources (62%), the opportunity cost of the building (15%), consumables (11%), depreciation cost of equipment (9%), and electricity charges (4%).

Conclusion: The per-test costs of immunoassays were estimated to be in the range of SLR.886 to SLR.6364. The tariffs of the leading private hospital network were found to be much higher (158% to 1260%) than the per-test costs at NHSL.

Recommendation: Considering the overwhelming contribution of reagent costs to the total per-test costs of immunoassays (87% to 98%), the efficient and effective sourcing of reagents could be the amicable way to contain the expenses for immunoassays.

Keywords: Per-test cost, Immunoassays, Laboratory costing, National Hospital of Sri Lanka

1. Introduction

1.1. The need for laboratory costing in state hospitals of Sri Lanka

Hospitals are consuming a larger portion of healthcare resources that are otherwise assumed to be scarce (Newbrander & Lewis, 1999). It was estimated that 74% of total healthcare expenditure across Sri Lanka was incurred by hospitals (Minsitry of Health Sri Lanka, 2022). Healthcare policymakers and managers are keen on measuring the cost of services they are providing to make comparisons among institutions. This cost-based comparison helps them improve the efficiency, effectiveness, quality, and sustainability of the care services they are spending (Newbrander & Lewis, 1999). The same thing is emphasized for not-for-profit hospitals or state hospitals to overcome the criticism against them over inefficiency in operations (Duggal & Budden, 2010). Efficient management of resources is crucial in government hospitals to sustain free health services amidst the rising out-of-pocket expenditures in Sri Lanka. Expenditure for laboratory investigations was found to be an important contributor to out-of-pocket expenditures (Kumara & Samaratunge, 2016).

Increasing expenditures for laboratory services is considered to be a challenge for free health services in Sri Lanka. Previous studies recommended the implementation of cost-reduction strategies to optimize laboratory services in state hospitals (Perera et al., 2022).

1.2. The National Hospital of Sri Lanka (NHSL)

The NHSL is the apex referral center of the country with a bed capacity of 3404 and is managed by the state (RANASINGHE, n.d.). The NHSL performed 4,091,146 lab tests in the year 2022, out of them 141,625 tests were immunoassays (Statistics Unit, National Hospital of Sri Lanka).

1.3. Immunoassays

"Immunoassays are bioanalytical methods in which the quantitation of the analyte depends on the reaction of an antigen (analyte) and an antibody. Immunoassay methods have been widely used in many important areas of pharmaceutical analysis such as diagnosis of diseases, therapeutic drug monitoring, clinical pharmacokinetic and bioequivalence studies in drug discovery and pharmaceutical industries" (Darwish, 2006). In hospital settings, their application is mainly confined to disease diagnosis and therapeutic drug monitoring.

1.4. Research problem

Immunoassays are among the most expensive group of laboratory tests in hospitals (Ali Mouseli1, 2 et al., 2017). Being managed by the government and providing services free of care, the institutions under the Ministry of Health, Sri Lanka don't have systems to trace expenditures on a patient or activity basis. Despite largest hospital in the nation with a heavy turnover of laboratory testing, NHSL has no mechanism to measure the cost incurred for each test or identify the contributors to the cost. The compelling need felt in the recent past following the economic crisis, to optimize the spending on care services at government hospitals to sustain free healthcare services in Sri Lanka (RANASINGHE, n.d.). Optimization of services by efficient and effective utilization of resources cannot be achieved without understanding the present situation through detailed cost analysis.

1.5. Objective

The study's objective was to estimate the per-test cost of immunoassays at the National Hospital of Sri Lanka and compare that with the private sector tariffs.

2. Methods

The single-setting costing study was conducted at the Immunoassay Laboratory of the NHSL from July to August 2023. The bottom-up micro-costing method was applied with the combination of a top-down approach to calculate indirect costs (Špacírová et al., 2020). The laboratory activities for the year 2022 were scrutinized. Total number of tests performed during the period was obtained from lab records. The testing process is mapped from blood collection to delivery of reports. The complete list of resources (cost categories) utilized in the process was identified and documented. Those resources were quantified and valued (Tan et al., 2012) (Niasti et al., 2019).

2.1. Process mapping

Collection of blood at Wards/OPD/Clinics → Reception of samples at the counter of immunoassay laboratory by healthcare assistants → Processing of samples by Medical Laboratory Technologists (MLTs) → quality check-up of Auto Analyzers by the biochemist and MLTs (plus periodic calibrations) → Loading samples and running tests → Completing cycles and checking results (retesting if results unsatisfactory) → Printing reports and dispatching to clinical centers

There were two Fully Automated Immunoassay Analyzers in almost similar capacities performing 24 different immunoassays (tests). The operational hours of the machines were fixed from 8 a.m. to 4 p.m. daily. Except few consumables (e.g. clot activator tubes) supplied by the Medical Supplies Division (MSD) of the Ministry of Health, all expenses for immunoassays are incurred by the NHSL.

2.2. Cost categories

2.2.1. Direct cost

The reagent cost (for a single test) was the only cost that could be straightforward attributable to the per-test cost of each test. As it is exclusively used for a particular single test, it is considered a direct cost (Broughton & Hogan, 1981). The reagent costs were extracted from the purchase orders. The costs of quality check-ups and calibrations were included in the reagent costs (by the supplier).

2.2.2. Indirect costs

These are the costs that cannot be attributed to a single test. Instead, these costs are shared by a group of tests (Broughton & Hogan, 1981). Therefore, the monthly/daily average indirect costs are estimated and divided by the monthly/daily average number of immunoassays (tests) done. Resultant amounts are added to the per-test costs of each test.

Human resources

One Chemical Pathologist, one Biochemist, five MLTs, and two healthcare assistants were the team that operated the lab. Their monthly average salaries, allowances, and extra duty payments were estimated by the pay information from the Accounting Department of NHSL.

Consumables directly used in lab tests

Average monthly consumption estimated from the lab store records and their unit prices extracted from the MSD.

Cleaning materials, stationery, and printing cost

Average monthly consumptions estimated from relevant stores. Their prices were extracted from the Supplies Department of NHSL.

Electricity

The electricity consumption was estimated with the help of experts, based on the daily average power consumption of electrical appliances used (e.g. analyzers, air conditioners, refrigerators, etc.). It was divided by daily average tests (total tests per day) and the cost was equally distributed.

Maintenance cost of equipment

The repair and maintenance of analyzers were undertaken by the supplier free of charge. The maintenance cost of other appliances was found to be negligent.

Depreciation cost of analyzers and other appliances

The Straight-Line method (SLM) was applied to estimate the replacement cost of equipment used per test (Liapis & Kantianis, 2015). The equipment procurement cost was adjusted to the cost of current equivalent machines (RICS, 2018). The depreciation period of analyzers were determined as 15 years (Ali Mouseli1, 2 et al., 2017) and other appliances as 8 years (Newbrander & Lewis, 1999) based on experts' opinion.

The opportunity cost of building space

The building has an estimated space of 750 square feet. The opportunity cost was estimated according to the commercial rent-out price of the area.

Other indirect costs that were ignored

The overhead costs of clinical (sample collection and transport), administrative, logistics, and maintenance units of the hospital were not added to lab expenditures as it was negligible in such a massive multi-specialty hospital. Likewise, the telecommunication (online-based laboratory information management system was yet not established) and water expenses were also found to be ignorable.

Total costs per test were calculated by adding per-test reagent costs with per-test indirect costs. Finally, the total costs per test were compared with the tariffs of the largest private hospital network in Sri Lanka.

3. Results

3.1. Reagent costs (Direct costs)

The per-test regent costs of immunoassays performed at NHSL were (per-test costs of each test are mentioned in respective brackets): TSH (SLR.772), T4 (SLR.846), T3 (SLR.856), Troponin I (SLR.1472), I PTH (SLR.1626), Cortisol (SLR.1149), PSA (SLR.1948), CA 125 (SLR.2242), Ferritin (SLR.882), Prolactin (SLR.1010), Vitamin D (SLR.3465), Estradiol (SLR.1010), DHEAS (SLR.2088), Beta HCG (SLR.1010), CEA (SLR.1640), CA 19-9 (SLR.1604), Insulin (SLR.1780), C-Peptide (SLR.1626), FSH (SLR.1010), LH (SLR.1010), Progesterone (SLR.1164), Testosterone (SLR.1269), AFP (SLR.1164), and PCT (SLR.6250) (Table 1).

Table 1: Description of immunoassays performed at NHSL with reagent cost per test in 2022

Name of the Test	No. of tests done	Reagent cost per test (SLR*)
TSH (Thyroid Stimulating Hormone)	51175	772
Free T4	46,344	846
Free T3	432	856
Troponin I	11224	1472
I PTH (Intact Para Thyroid Hormone)	345	1626
Cortisol	4250	1149
Total PSA (Prostate Specific Antigen)	2608	1948
CA 125 (Cancer Antigen-125)	703	2242
Ferritin	9005	882
Prolactin	798	1010
Vitamin D	2927	3465
Estradiol	196	1010
DHEAS (Dehydroepiandrosterone sulfate)	77	2088
Beta HCG (Human Chorionic Gonadotropin)	543	1010
CEA (Carcinoembryonic Antigen)	903	1640
CA 19-9 (Cancer Antigen 19-9)	756	1604

Insulin	72	1780
C-Peptide	103	1626
FSH (Follicle Stimulating Hormone)	1225	1010
LH (Luteinizing Hormone)	1158	1010
Progesterone	50	1164
Testosterone	959	1269
AFP (Alfa Feto Protein)	1087	1164
PCT (Procalcitonin)	3737	6250
Other tests^	948	-
Total	**141625**	

* Sri Lankan Rupees ^ tests currently not performed e.g. COVID antibody

3.2. Indirect costs

The indirect costs of immunoassays at NHSL per test were: salaries & allowances [Specialist SLR.2 (2%), Biochemist SLR.8 (7%), MLTs SLR.33 (29%), HCAs SLR.7 (6%)], extra duty payments [Specialist SLR.1 (1%), Biochemist SLR.0 (0%), MLTs SLR.17 (15%), HCAs SLR.2 (2%)], consumables [MSD supplies SLR.9 (8%), stationaries & printing SLR.3 (3%), cleaning items SLR.1 (1%)], services & repairs of analyzers SLR.0 (0%), electricity charges SLR.4 (4%), depreciation cost [analyzers SLR.8 (7%), general equipment SLR.2 (2%)], and the opportunity cost of the building SLR.17 (15%) (Table 2).

Table 2: Description of indirect costs for immunoassays at NHSL per test in 2022

Cost elements		**Cost per test (SLR)**	**Percentage (%)**
Salaries & allowances	Specialist	2	1.75
	Biochemist	8	7.02
	MLTs	33	28.95
	HCAs	7	6.14
Extra duty payments	Specialist	1	0.88
	Biochemist	0	0.00
	MLTs	17	14.91
	HCAs	2	1.75
Consumables	MSD Supplies	9	7.89
	Stationaries & printing	3	2.63
	Cleaning items	1	0.88
Service & repairs	Analyzers	0	0.00
Electricity charges		4	3.51
Depreciation cost	Analyzers	8	7.02
	General equipment	2	1.75
Opportunity cost	Building	17	14.91
Total		**114**	**100.00**

3.3. Total costs (per test)

Total per-test costs of immunoassays at NHSL (with percentage of contribution from direct and indirect costs) were: TSH SLR.886 (87% & 13%), free T4 SLR.960 (88% & 12%), free T3 SLR.970 (88% & 12%), Troponin I SLR.1586 (93% & 7%), I PTH SLR.1740 (93% & 7%), Cortisol SLR.1263 (91% & 9%), total PSA SLR.2062 (94% & 6%), CA 125 SLR.2356 (95% & 5%), Ferritin SLR.996 (89% & 11%), Prolactin SLR.1124 (90% & 10%), Vitamin D SLR.3579 (97% & 3%), Estradiol SLR.1124 (90% & 10%), DHEAS SLR.2202 (95% & 5%), Beta HCG SLR.1124 (90% & 10%), CEA SLR.1754 (94% & 6%), CA 19-9 SLR.1718 (93% & 7%), Insulin SLR.1894 (94% & 6%), C-Peptide SLR.1740 (93% & 7%), FSH SLR.1124 (90% & 10%), LH SLR.1124 (90% & 10%), Progesterone SLR.1278 (91% & 9%), Testosterone SLR.1383 (92% & 8%), AFP SLR.1278 (91% & 9%), and PCT SLR.6364 (98% & 2%) (Table 3).

Table 3: The per-test costs of immunoassays at the NHSL in 2022

Name of the Test	**Reagent**		**Indirect**		**Total**	
	Cost (SLR)	**%**	**Cost (SLR)**	**%**	**Cost (SLR)**	**%**
TSH	772	87	114	13	886	100
Free T4	846	88	114	12	960	100
Free T3	856	88	114	12	970	100

Troponin I	1472	93	114	7	1586	100
I PTH	1626	93	114	7	1740	100
Cortisol	1149	91	114	9	1263	100
Total PSA	1948	94	114	6	2062	100
CA 125	2242	95	114	5	2356	100
Ferritin	882	89	114	11	996	100
Prolactin	1010	90	114	10	1124	100
Vitamin D	3465	97	114	3	3579	100
Estradiol	1010	90	114	10	1124	100
DHEAS	2088	95	114	5	2202	100
Beta HCG	1010	90	114	10	1124	100
CEA	1640	94	114	6	1754	100
CA 19-9	1604	93	114	7	1718	100
Insulin	1780	94	114	6	1894	100
C-Peptide	1626	93	114	7	1740	100
FSH	1010	90	114	10	1124	100
LH	1010	90	114	10	1124	100
Progesterone	1164	91	114	9	1278	100
Testosterone	1269	92	114	8	1383	100
AFP	1164	91	114	9	1278	100
PCT	6250	98	114	2	6364	100

The per-test costs of immunoassays at NHSL were compared with respective tariffs at the private hospital by deducting NHSL cost from the private hospital tariff and the percentage of differences was calculated. The results were (differences in SLR and the percentage of differences respectively): TSH (+1594, 280%), Free T4 (+1540, 160%), Free T3 (+1530, 158%), Troponin I (+5124, 323%), I PTH (+13160, 756%), Cortisol (+4377, 347%), Total PSA (+8418, 408%), CA 125 (+9014, 383%), Ferritin (+1874, 188%), Prolactin (+2876, 256%), Vitamin D (+8931, 250%), Estradiol (+5206, 463%), DHEAS (+4918, 223%), Beta HCG (+4466, 397%), CEA (+7766, 443%), CA 19-9 (+21652, 1260%), Insulin (+4966, 262%), C-Peptide (+7810, 449%), FSH (+2876, 256%), LH (+2876, 256%), Progesterone (+4232, 331%), Testosterone (+4977, 360%), AFP (+6122, 479%), and PCT (+9986, 157%) (Table 4).

Table 4: Comparison of per-test costs of immunoassays at NHSL and private sector tariffs

	Cost per test (SLR)		**Difference***	
Name of the test	**NHSL**	**Private Hospital**	**Cost (SLR)**	**(%)**
TSH	886	2480	+1594	280
Free T4	960	2500	+1540	160
Free T3	970	2500	+1530	158
Troponin I	1586	6710	+5124	323
I PTH	1740	14900	+13160	756
Cortisol	1263	5640	+4377	347
Total PSA	2062	10480	+8418	408
CA 125	2356	11370	+9014	383
Ferritin	996	2870	+1874	188
Prolactin	1124	4000	+2876	256
Vitamin D	3579	12510	+8931	250
Estradiol	1124	6330	+5206	463
DHEAS	2202	7120	+4918	223
Beta HCG	1124	5590	+4466	397
CEA	1754	9520	+7766	443
CA 19-9	1718	23370	+21652	1260
Insulin	1894	6860	+4966	262
C-Peptide	1740	9550	+7810	449
FSH	1124	4000	+2876	256
LH	1124	4000	+2876	256
Progesterone	1278	5510	+4232	331
Testosterone	1383	6360	+4977	360
AFP	1278	7400	+6122	479
PCT	6364	16350	+9986	157

*Difference = private hospital tariff for particular test – respective per test cost at NHSL

4. Discussion

4.1. Study design

The study adopted the bottom-up micro-costing approach to estimate the per-test cost of immunoassays at NHSL, even though a systematic analysis said that 86% of healthcare costing studies followed a top-down approach (Špacírová et al., 2020). However, there were critics that the top-down method was used to make arbitrary assumptions in the apportions of overhead and indirect costs to final cost centers, without considering the inputs and outputs of activities performed (Polasi, 2015). Yet, the same study accepted the difficulties in generalizing the methodologies of a bottom-up approach to other hospitals as they are less flexible and more context-specific. A research paper highlights the usage of the bottom-up micro-costing method when the cost data is collected at the unit level and detailed elements are identified for costing (Špacírová et al., 2020) (Chapko et al., 2009). It recommends the approach to measure a single cost object (e.g. lab test). Still, the study accepts the need for a top-down method for measuring indirect costs. Therefore, it proposes a new method for the future with the combination of both bottom-up and top-down approaches. The costing studies are known to adopt particular methods for a long time to estimate per-test costs for laboratory investigations (Broughton & Hogan, 1981). Each costing method has its purpose and complements each other (Marques & Alves, 2023).

The above arguments fortify the adoption of a bottom-up micro-costing method in this study with a top-down approach to measure indirect costs, the methodology seems to be robust enough to produce valid results.

This study defined the daily/monthly average immunoassays at NHSL as a single cost driver to apportion indirect costs to per-test costs. Such an approach made things easier to measure and allocate costs (Ali Habibi, 2012). The bottom-up method applied for the estimation of daily/monthly consumption of electricity proved to be an effective and valid method to measure power consumption for a specific setting (Menezes et al., 2014).

4.2. Findings

Considering the findings, the per-test costs of immunoassays at NHSL fell in the range of SLR.886 to SLR.6364. The test for Thyroid Stimulating Hormone (TSH) costs the least while the test for procalcitonin (PCT) costs the most. It was checked with the assistance of Pearson correlation whether the per-test costs of investigations were associated with the number of tests performed. There was no association between the per-test costs of investigations and the number of tests performed as Pearson $r(22) = -.19$, $P = .367$.

It estimated that the indirect cost per test of immunoassays at NHSL was SLR.114. The salaries and allowances of the laboratory workforce contributed the most to indirect costs (44%), followed by extra duty payments (18%), opportunity cost of the building space (15%), consumables (11%), depreciation cost of equipment (9%), and electricity charges (4%). Together 62% of the indirect costs per test were incurred by the expenses for human resources. The finding is generally agreed by other researchers (Ali Mouseli1, 2 et al., 2017) (Perera et al., 2022), irrespective of its (expenses for human resources) inclusion under direct or indirect cost depending on their methodology.

When considering the expenses (salaries, allowances, and extra duty payments) for human resources; MLTs got the biggest share (44% of total indirect costs per test) followed by HCAs (8%), Biochemist (7%), and the Specialist (3%). The cost for the specialist was lesser as her services covered the biochemistry laboratory which had multiple times higher turnover than the immunoassay laboratory (accordingly the expenses were apportioned).

Interestingly, indirect costs add little to the total cost of immunoassays at NHSL as reagent costs alone contribute to 87% to 98% of total costs per test. The findings are in the direction of other costing studies (Ali Mouseli1, 2 et al., 2017) (Perera et al., 2022), but the proportion of contribution is much lesser. Some studies even suggest that half of the laboratory costs are incurred by general expenses apportioned to labs (Ninci & Ocakacon, 2004). However, such apportion is negligible at NHSL when considering its size and multi-dimensional service delivery.

Greater variations were observed between the per-test cost of immunoassays at NHSL and the tariffs of the largest private hospital network in the country. The cost for free T3 showed the least variation as the tariff was 158% higher than the estimated per-test cost at NHSL and the cost for CA 19-9 was found with the most variation as the tariff was 1260% higher than the estimated per-test cost at NHSL. The findings tally with the statement that prices charged at commercial laboratories no way the indicator of the actual cost incurred for those tests (Broughton & Hogan, 1981). When the Pearson correlation was applied to check the relationship between private tariffs and per-test costs at NHSL, it was moderately associated as Pearson $r(22) = .59$, $P = .002$. Low turnover for particular tests could be a reason along with profit margin for determining such high differences. No information was available on the numbers of each test performed by the private hospital network to find any association (correlation) between the tariffs and the number of tests performed.

4.3. Limitations

The steep internal and external fluctuations in resources over a short period were the major limitations of the study, making the costing process extremely difficult. Being a government hospital, there is a huge variation in the grades and remunerations of staff categories. Each staff movement and turnover creates greater variation in costs for human resources. This study adopted a method to calculate the average expenses for each category by considering all these variations. The current Sri Lankan economic crisis often instills turbulences in currency value and taxes which is reflected in the prices of all services and goods. Again, multiple adjustments have been made to calculate the average costs of the elements included.

5. Conclusion

National Hospital of Sri Lanka is the largest hospital in the nation with a heavy turnover in laboratory testing, so far has no mechanism to measure the cost incurred for each test or identify the contributors to the cost. Immunoassays are among the most expensive groups of laboratory tests performed to diagnose diseases. It was emphasized in the recent past following the economic crisis, to optimize the spending on care services at government hospitals to sustain free healthcare services in Sri Lanka. Optimization of services by efficient and effective utilization of resources cannot be achieved without understanding the present situation through detailed cost analysis.

The per-test costs of immunoassays were estimated to be in the range of SLR.886 to SLR.6364 at NHSL. The tariffs of the leading private hospital network of the country were found to be much higher (158% to 1260%) than the per-test costs at NHSL.

5.1. Recommendation

The results of the study could apply to hospitals under the Ministry of Health Sri Lanka with provisions for variations due to hospital size and turnover. Considering the overwhelming contribution of reagent costs to the total per-test costs of immunoassays (87% to 98%), the efficient and effective sourcing of reagents could be the amicable way to contain the expenses for immunoassays. As reagents are supplied by the same suppliers of respective analyzers, efforts should be taken during the procurement of machines, to make decisions by comparing the prices of each reagent quoted for a fixed rate (both in SLR and USD to avoid price fluctuations).

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