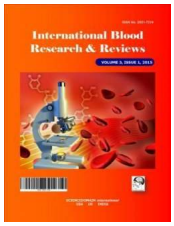

International Blood Research & Reviews
6(4): 1-17, 2016, Article no.IBRR.29818
ISSN: 2321–7219

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Pattern, Determinants, and Costing Review of Send-out Tests in a Secondary Care Hospital Setting in Saudi Arabia

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Authors' contributions

This work was carried out in collaboration between both authors. Author AAA designed the study, wrote the protocol, supervised field work, handled administrative and ethical issues, data collection process, costing plan and data entry. Author RA handled methodology, literature review, statistical analysis, results display and discussion and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IBRR/2016/29818
Editor(s):
(1) Dharmesh Chandra Sharma, Incharge Blood Component & Aphaeresis Unit, G. R. Medical College, Gwalior, India.
Reviewers:
(1) Heshu Sulaiman Rahman, Universiti Putra Malaysia, Malaysia.
(2) Salah Mesalhy Aly, Sue Canal University, Egypt.
(3) S. U. Arakeri, BLDE University, India.
(4) Manickam Tamilselvi, Value Added Health Care Services Pvt Ltd, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/16806

Original Research Article

Received 30th September 2016
Accepted 26th October 2016
Published 5th November 2016

ABSTRACT

Background: The need for advanced laboratory tests, mostly performed at reference laboratories, increases over time. Officials have to choose between "send-out" testing or introducing such tests among their test menus, bearing necessary cost.
Aim: This study aims to identify the distribution pattern of send-out testing at the A Hada Armed Forces Hospital (AHAFH), in Taif relevant cost and associated factors.
Methods: A study review of all send-out tests of all varieties during fiscal year (FY) 2011 was conducted.
Results: It was found that 2,986 reference laboratory tests out of total 3,675,000 tests were processed during the study period, comprising 0.11% of the total test volume. The total cost of send-

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out testing accounted up to €168,903.5 [range €370.8, minimum €12.2, maximum €383.0, median €50.0, inter-quartile range *(IQR)* €48.86], and constituting 11.7% of the total laboratory budget in fiscal year (FY) 2011. The variability in the cost of send-out tests was statistically significant *[H(6)=898.39, p<0.001].* The cost of send-outs highly correlated with the turnaround time (TAT) (r=0.77, p<0.001).

Conclusions: The study furnishes a database that can be used for conducting an in-depth cost-effectiveness analysis to help introduce priority reference tests to AHAFH laboratory test menu to minimize the "wait time" until disease diagnosis has been done. New measures to adjust send-out testing may be developed to help physicians make sound send-out decision choices.

Keywords: Send-out tests; reference laboratories; Saudi Arabia.

1. INTRODUCTION

Laboratory testing plays a pivotal role in clinical health problems diagnoses and follow-up. The ongoing scientific and technological advances have changed the way that clinical laboratories diagnose and manage many diseases. Now, there is an increasing demand by a wide sector of the healthcare provider's community on the utilization of advanced laboratory procedures. Such tests have the ability to confirm the presence of specific diagnoses, like never before. Given their excellent sensitivity, specificity, and speed, molecular assay techniques, for instance, have drastically improved the diagnosis of infectious diseases (IDs), until they are often considered as a reliable alternative to traditional culture or enzyme immunoassay (EIA) methods [1]. As such, virtually all hospitals unsurprisingly send laboratory tests to outside reference laboratories. Typically, the "send-outs" are low-volume esoteric tests that require special skills or expensive technologies beyond the scope of the hospital laboratory. Over time, there has been an increase in the complexity of the test menu with the emergence of a large number of the molecular-based diagnostics. As a consequence, reference laboratory testing on the national levels has become a multi-billion-dollar business [2]. Often, commercial reference laboratories have the capacity to transport and process large volumes of samples and offer a diverse test menu. Although such capacity may result in a lower unit cost, the charges may still be higher than can be achieved in the hospital setting. While healthcare budgets worldwide are facing increasing emphasis to reduce costs and improve efficiency, yet maintain quality, laboratory testing has not escaped this pressure. In Britain, pathology investigations alone cost the National Health Service £2.5 billion per year [3]. The Carter Review (a UK Department of Health-commissioned review of pathology services) estimated that 20% of this budget could be saved by improving pathology services, despite an average annual increase of 8%-10% in workload. In a USA study based on 2002 reference laboratory testing demand and costing data, the investigators reported various metrics on laboratory testing in their hospital [4]. At the time, reference laboratory testing comprised only 1% of the total test volume but accounted up to 65.7% of the test menu and 12.4% of the total laboratory budget. One major factor contributing to the increasing cost comes from molecular diagnostic testing which has begun to emerge as an important component of the test menu.

In essence, laboratory medicine, like other health economy sectors, is under increasing pressure to remove inefficiencies and reduce costs, while maintaining or indeed improving standards. To this end, reference laboratory expenses are still out of control. With new complex and specialized testing options on the rise, many laboratories will keep seeing a significant increase in overall expenses. The issue is that spending more on testing could mean making cuts in other service areas, resulting in a negative impact upon the laboratory's bottom line, and probably the overall health institution's operations. With all this in mind, laboratorians are left up with the need to answer questions of test quality, cost effectiveness, and whether to refer testing to a reference laboratory [5]. Above all, cost is not the only reason facing expansion in modern sophisticated laboratory techniques that make diagnosis of certain complex diseases more achievable. Other causes, e.g., practitioners' test requesting attitude, contribute to this challenge. As in the British reference laboratory testing experience [3], there is an estimated 25% unnecessary pathology test requests, largely linked to a wide variability in levels of requesting between general practitioners. Unlocking the key to this variation, implementing measures to reduce inappropriate requesting would have

major implications for patients and healthcare resources alike. Thereby, one area of increasing importance to cut on laboratory costs, meanwhile not impacting quality of patient service, is managing the demands for expensive procedures, such as pathology tests through reducing their inappropriate requesting. Such quest, e.g., first needs to define demand management, drivers for inappropriate requesting, and also to examine some technicalities, such as electronic requesting procedure used. The study of the demand management is crucial, e.g., selecting appropriate educational approaches and key performance indicators needed both to improve and assess clinician's test selection capacity, and hence evaluate unfavorable incidents such as duplicate requests and the profile composition of downstream impact of inappropriate requesting.

1.1 The Saudi Healthcare Arena

Health care services in Saudi Arabia have been given a high priority by the government. During the past few decades, health and health services have improved greatly in terms of quantity and quality [6]. The Saudi society's spending on health comes from four main sources: government-funded services, including ministry of health (MOH) auspices which undertakes 59.5% of the service volume, other governmental health agencies which undertake 19.3% of the service volume, [including armed forces health services, security forces medical services, health services in the Royal Commission premises, and health services in the oil industry (run by the sole national oil industry owner in the country called Arab American Oil Company - ARAMCO)], and the private sector, which shares as much as 21.2% of overall spending on health [7]. In fact, the health care movement in Saudi Arabia sees a fast development in all health sectors, including the armed forces', which strive to catch up with the highest quality standards achieved in the developed western models. Gallagher has stated that: "Although many nations have seen sizable growth in their health care systems, probably no other nation other than the Kingdom of Saudi Arabia (KSA) of large geographic expanse and population has, in comparable time, achieved so much on a broad national scale with a relatively high level of care made available to virtually all segments of the population" [8]. And according to the World Health Organization (WHO) [9], the Saudi health system is ranked 26th among 190 of the world's health systems, ranking before many international health systems such as Canada and other systems in the region. As a consequence, the health of the Saudi population has markedly improved in recent decades. However, a number of issues pose challenges to the healthcare system, such as shortage of Saudi health professionals, limited financial resources, changing patterns of disease, and high demand resulting from free services for Saudi citizens in the governmental healthcare facilities. In parallel, speedy communication and instantaneous exchange of information globally, all have led to an escalation of people's expectations toward today's medicine as to find prompt solutions to their health problems, whether from the therapeutic or the diagnostic standpoint. This perspective puts clinicians, health professionals, and decision makers under continuous pressure of the need to meet the people's health needs and live up to their expectations.

In the armed forces health services, the situation is not a departure from that in the general Saudi healthcare environment. First, AHAFH laboratory is CAP (college of American pathologists) – certified and embraces policies and procedures that assure commitment to quality service and continuous staff development. Nonetheless, the stressing need to meet clinicians' requirements to pin point diagnoses, causes, and certain specific criteria of some complex diseases intimidate using advanced laboratory tests on an increasingly growing basis. To that end, the hospital's laboratory currently, and probably through the near-remote future, tends to use send-out testing to reference laboratories mostly in Europe, (such as German Biocientia Laboratories and French Laboratories Marcel Merieux), to provide the requested diagnostic criteria for the clinical health problems that supposedly mandate such testing. This tendency is traditionally justified by the large number of the currently available tests, as above. These tests involve more steps and more manual processes than in-house tests, thereby increasing the risk of errors that can cause patient harm [10]. The laboratory is now challenged with an inflated budget provision of reference laboratory tests. As a concern, too, is the wait time both the clinical system requirement and the patient have to bear until the test result for the clinical problem under investigation has been released. This work aimed to study the volume and distribution pattern of send-out tests at AHAFH, analyzing associated costs and underlying costing policy. Studied were correlates associated with the cost and turnout time trends, including physicians'

attitude toward ordering send-out tests at different clinical settings and affiliations.

2. METHODS

2.1 The Study Setting

Lying in Taif city, west KSA district, AHAFH is a 400 -bed secondary healthcare institution catering for military personnel and military veterans and their families. The hospital offers a comprehensive health care package to eligible persons, including inpatient, outpatient, intensive care, operative, and emergency services. In the FY 2009, the hospital admitted 59,404 inpatients and received over 1 million visits to outpatient facilities. Onsite, laboratory department is dynamic and assumes a multidisciplinary service to provide better diagnostic, research, and treatment monitoring opportunities to the hospital. The laboratory inspires providing accurate, reliable and timely diagnostic service to meet the needs of the clinical programs of AHAFH. It is keen to improve the effectiveness and economic aspects of all laboratory activities through quality management and staff development. The laboratory delivers comprehensive diagnostic and interpretive services in histopathology, cytology, clinical chemistry, microscopy, hematology, immunology, microbiology, blood bank and transfusion medicine, flow cytometry and molecular pathology (molecular microbiology, molecular genetic pathology, and morphologic molecular pathology cytogenetics). Widely incorporated, too, is a broad array of tests involving pathology's new developments in molecular biology and diagnostic biotechnology.

2.2 Study Design and Data Collection

Send-out testing data retrieved from AHAFH laboratory information system for the fiscal year 2011 have been reviewed. Important criteria, such as the pattern, distribution, as well as correlates relevant to reference laboratory tests, including costing and time trends have been analyzed. Approval to conduct the research was first obtained from AHAFH research ethics committee. Also formal permissions to retrieve and analyze laboratory data of interest were obtained from the concerned hospital's authorities. No individual patient's information disclosure was permitted and only anonymous results would be displayed in scientific research settings. A proforma was designed to collect information necessary to achieve study aim. The proforma includes a number of items (18) covering the main fields, such as test scientific name, coding, category, sending date, reference laboratory data, turnaround time (TAT), requesting party information and coding, test result as stated by reference lab an result typifying, and cost per-test information. The TAT is estimated as the duration in days from the date of sending out until the date of receiving the result. Send-out test cost is estimated as the price determined by the reference laboratory in Euro against: a) full test running, b) designated container/collection vehicle to be sent from the reference laboratory to AHAFH laboratory by international and domestic courier, c) transportation cost for returning test result by courier including shipping and handling expenses, and d) insurance coverage. (*NB.* On the reference laboratory's part, cost includes all direct and indirect costs and expenses, and taxes the laboratory incurs as a commercial entity on its homeland; other indirect costs, overheads, and expenses, such as the cost of phlebotomy, employee time, utilities, are incurred by AHAFH but not included in our send-out test pricing). The send-out tests were classified into seven major laboratory test categories: 1) immunochemistry, 2) clinical chemistry, 3) hormonology, 4) molecular biology, 5) microbiology, 6) tissue typing, and 7) histopathology. All tests requested five times or more during FY 2011 would be included into the study; tests requested less than five times would be excluded.

2.3 The Study Variables

All categorical data on the data collection sheet where of nominal nature (dichotomous). For instance, laboratory test category includes any of a) send-out test- laboratory category (see above), b) requesting department/unit, c) diagnostic category (screening test, diagnostic test, confirmatory test), and d) test result ("positive", "negative" or "abnormal". The study contains only two continuous variables: Test cost in Euro and TAT in days; both are envisioned as outcomes of interest in the analytical phase of the study (see later).

2.4 Data Management and Analysis

Data would be entered into a Microsoft (MS) program with adequate back up; and made ready for statistical analysis. First, descriptive statistics would be conducted, e.g., count and proportion for categorical data, and mean ± standard

deviation (SD) or median and inter-quartile range (IQR) for continuous data, where appropriate (depending on normality distribution), such as age and test cost. Next would be to calculate appropriate statistical techniques to analyze and draw inferences about the studied data. Parametric techniques (PMT), e.g., student *t*-test of two independent samples, could be used comparing mean differences, considering normality assumption. Otherwise, non-parametric technique (NPMT) alternative Mann-Whitney *U* test could be calculated. Testing the differences between > two groups for the mean differences of a continuous variable of interest, one-way analysis of variance (ANOVA) test would be calculated, considering normality and other applicable assumptions. Otherwise NPMT, e.g., Kruskal Wallis test could be calculated. Either a Pearson correlation or a Spearman's rho, depending on normality distribution, too, comparing the strength of correlation between any two continuous variables could be attempted. (Normality of the studied continuous data could first be determined, e.g., using Kolmogorov-Smirnov test). Often other NPTs, e.g., chi-square test or Fisher's exact, where appropriate, would be used, to measure the association between categorical variables. In which case, the odds ratio (OR) and its 95% confidence interval (CI) may be used to express the strength and significance of such association, respectively. The SPSS software for MS-version-20 was used for statistical analysis. All tests were at level of significance α=0.05, and results with *p*-values <0.05 were considered "statistically significant."

3. RESULTS

As in Table 1, the total number of send-out tests in FY 2011 accounted 2,986 tests. Since the total number of all tests performed in AHAFH laboratory during 2011 totaled 3,675,000 tests, send-out testing volume mounts to slightly over 1/1000 (0.11%). The maximum cost was €383.00 per test and this applied to some "histopathology" tests. The total cost of send-out testing from all test categories was €168,903.5 (out of €1,443,619.6 = 11.7%), with a median cost €50.00±48.86 *IQR* per test. The median TAT was 12±11 *IQR* days. Least TAT- awaited was two days (two drug screening tests), longest was 131 days (TNF-Alpha, interlukin-1 beta, interlukin-6 beta, 3 tests each).

Table 2 shows that more than half of test volume belongs to immunochemistry class (1532= 51.3%) and clinical chemistry class (985= 33.0%).then rates sharply decline, e.g., molecular biology 225 (8.5%) tests; microbiology, tissue typing, and histopathology 15(0.50%), 15(0.50%), 11 (0.40%), respectively. Regarding the types within each test category, microbiology, tissue typing, and histopathology, each contained only one test technique.

As in Table 3, screening test rate was highest among all diagnostic test categories (1683/2986 = 56.4%), next come confirmatory tests (758/ 2986 = 25.4%), least diagnostic tests (545= 18.2%).

Table 1. Descriptive analysis of the study's continuous variables: Cost and turnaround time (TAT) of send-out tests n=2,986

Characteristic	Cost (Euro) €*	Turnaround time	
		Day*	Remarks
Minimum	12.20**	2	† 2 tests
Maximum	383.00***	131	├ 9 tests
Range	370.80	129	
Total	168,903.46		
	(out of total 1443619.6)	-----	
Average	56.56	15.52	
Standard deviation	48.79	12.99	
Median	50.00	12.00	
Interqualrtile range (IQR)	48.86	11.00	

** Kolmogorov-Smirnov-Z: Cost 10.27, p<0.001, TAT 13.41, p<0.001 ** Immunochemistry*
**** Histopathology (renal biopsy) † Clinical chemistry (drug opiates)*
├ Immunochemistry (3 tests TNF-Alpha, 3 tests interlukin-1 beta, 3 tests interlukin-6 beta, 3)

Table 2. Distribution pattern of send-out tests according to laboratory test category

#	Send-out test laboratory category	Frequency	%	Remarks
1	Immunochemistry	1532	51.3	Variable types, >30 tests
2	Clinical chemistry	985	33.0	Variable types, >20 tests
3	Hormonology	255	8.5	Variable types, >5 tests
4	Molecular biology	173	5.8	3 types
5	Microbiology	15	0.50	All tuberculosis (TB) culture
6	Tissue typing	15	0.50	All tissue typing requests (HLA-B27)
7	Histopathology	11	0.40	All renal biopsy
	Total	2986	100%	

Table 3. Distribution pattern of send-out tests according to diagnostic category

	Frequency	%
Screening tests	1683	56.40
Confirmatory test	758	25.40
Diagnostic test	545	18.20
Total	2986	100.00

In Table 4, pediatrics send-out testing were most reported (37.7%). Rates then decrease gradually for other departments. Likewise, pediatricians were the greatest user of immunochemistry testing (651= 21.8%). [Important immunochemical procedures include ELISA, apoptosis assays, and IA techniques]. Pediatrics also outnumbered all departments in some other test categories requisition [82(6.2%) hormonology, 14(0.5%) rheumatology]. Histopathology requests (11= 0.4%) were mere nephrology utilization. Specifically, rheumatology utilized almost all tissue typing testing [14(0.5%), out of 15 tests, and only 1 test was requested in the hematology department].

In Table 5, negative send-out test result predominate (39.92%) over other results. Positive result comes next (23.51%), followed by "normal" result (18.55%). Other test result types reported lower request rates (e.g., "high" result 9.24%, "abnormal" result. Immunochemistry tests constitute the vast majority of negative test results (1015/1192=85.15%). Negative immunochemistry tests also constitute the majority of all test types (1015/2986 = 33.92%).

Table 4. Distribution pattern of send-out tests by department and test category (n= 2,986)

Department*		Send-out test laboratory category							
		Immuno-chemistry	Clinical chemistry	Hormon-ology	Molecular biology	Micro-biology	Tissue typing	Histo-pathology	Subtotal 2986 *
Pediatrics	n	651	210	184	82	0	0	0	1127
	%	21.8	7.0	6.2	2.7	0.0	0.0	0.0	37.7
Recruitment	n	0	399	0	0	0	0	0	399
clinic	%	0.0	13.4	0.0	0.0	0.0	0.0	0.0	13.4
Rheumatology	n	262	2	1	0	0	14	0	279
	%	8.8	0.1	0.03	0.0	0.0	0.5	0.0	9.3
Internal	n	143	44	14	20	0	0	0	221
medicine	%	4.8	1.5	0.5	0.7	0.0	0.0	0.0	7.4
Nephrology	n	72	112	14	0	0	0	11	209
	%	2.4	3.8	0.5	0	0.0	0.0	0.4	7.0
Gastro-	n	181	19	0	1	0	0	0	201
enterology	%	6.1	0.6	0.0	0.03	0.0	0.0	0.0	6.7
Neonatology	n	100	57	4	31	0	0	0	192
	%	3.3	1.9	0.1	1.0	0.0	0.0	0.0	6.4
Subtotal	n	1311	751	203	134	0	14	0	2413
	%	43.9	25.1	6.8	4.5	0.0	0.5	0.0	87.8

***** *Endocrinology 2.3%, Family medicine 2.4%, Neurology 1.4%, OB&GYN 1.4%, Psychology 1.4%, Employee clinic 1.07%, Hematology 0.77%, Infectious diseases 0.77, ENT 0.4%, ICU 0.2%, Laboratory 0.1%. (Subtotal = 12.2%). Total test volume proportion = 87.8 = 12.2 = 100%*

Table 5. Distribution of send-out test result as released from the reference laboratory for each laboratory test category

#	Test result category	n	%	Send-out test laboratory category *							*p*-value
				1	2	3	4	5	6	7	
1	Negative	1192	39.92	1015	150	----	12	0	15	----	
2	Positive	702	23.51	354	333	----	0	15	0	----	
3	Normal	554	18.55	106	218	94	136	----	----	0	**<0.001**
4	High	276	9.24	48	190	41	----	----	----	----	
5	Low	202	6.76	9	73	120	----	----	----	----	
6	Abnormal	60	2.01	----	21	----	25	----	----	11	
	Total	2986	100.00	1532	985	255	173	15	15	11	

***1 Immunochemistry, 2 Clinical chemistry, 3 hormonology, 4 molecular biology, 5 microbiology, 6 tissue typing, 7 histopathology*

***Chi-square Test: [χ^2(df=30) = 2931.99, p< 0.001]*

*[**NB.** Not all result categories have to apply to all laboratory test categories. Some tests could only be either positive or negative, and so forth. Inapplicable result types are marked by a dotted line in the corresponding cells of Table 5 (redundant ells)].* The variability in the test result significantly depended on test type [χ^2(df=30) = 2931.99, p< 0.001]. (See also Table 5 footnote). For instance, all histopathology tests (11, 0.4%) were "abnormal", none was "normal". In other words, all renal biopsies taken in the hospital had abnormal histological findings. Likewise, microbiology tests (15 = 0.5%) are all "positive" [all *TB* culture and sensitivity (C/S) requests proved positive]. Conversely, all tissue typing results (15 = 0.5%) reported negative. (Also see Table 2 for proportions).

Table 6 indicates that some test categories (histopathology, microbiology, tissue typing), include only one test (e.g., histopathology: all kidney biopsy; microbiology: All culture and sensitivity; tissue typing: All HLA typing). Thereby, identical price might be seen on these accounts (minimum, maximum, median are all the same). The median cost per unit test for the study data (€383.00) equals maximal cost for histopathology testing (€383.00) and least for hormonology testing (€35.99). Tests of moderate cost include clinical chemistry (median €76.00) and tissue typing (median €67.53). Test categories varied significantly in their cost levels [*H*(df=6) = 898.39, *p*= 0.001], (Table 6 footnote).

Table 7 shows that histopathology results were latest to receive (median TAT 30 days); while both, tissue typing and hormonal test results were earliest to receive (median TAT: 8 days and 6 days, respectively). The difference between TAT levels was statistically significant [*H*(6) 487.383, *p*<0.001], (Table 7 footnote).

Table 6. Distribution pattern of send-out testing by cost characteristics (n= 2,986)

Send-out test laboratory category	Minimum cost (€)	Maximum cost (€)	Range (€)	Median(€)	Mean (€)	SD (€)	Test category total cost	*p*-value
Histopathology (All are renal biopsy)	383.00	383.00	0.00	383.00	383.00	0.00	4213.00 (%2.25)	
Microbiology (All are C/S)	197.00	197.00	0.00	197.00	197.00	0.00	2955.00 (1.6%)	
Molecular biology (173=5.8%)	179.00	290.00	111.00	179.00	184.33	23.38	31889.70 (17.06%)	<0.001
Clinical chemistry	12.20	87.00	74.80	76.00	57.40	25.02	56573.12 (30.26%)	
Tissue typing (All are HLA typing)	67.53	67.53	0.00	67.53	67.53	0.00	1012.95 (0.54)	
Immunochemistry	12.20	290.00	278.00	33.84	41.20	32.38	63083.12 (33.75%)	
Hormonology	27.14	53.36	26.22	27.14	35.99	9.90	9176.59 (4.9%)	
Total	------	------	------	------	------	------	168,903.5	

**Kruskal Wallis Test: [H(df=6) = 898.39, p= 0.001]*

Table 7. Distribution pattern of send-out testing by turnaround time (TAT) characteristics (n= 2986)

#	Send-out test laboratory category	Minimum (day)	Maximum (day)	Range (day)	Median (day)	Mean (day)	SD (day)	p-value
1	Histopathology	19	49	30	30	30.80	8.59	
2	Molecular biology	8	77	69	26	27.30	12.34	
3	Microbiology	9	43	34	21	22.13	11.60	<0.001*
4	Clinical chemistry	2	210	208	15	17.07	11.16	
5	Immunochemistry	4	131	127	9	13.93	13.87	
6	Hormonology	4	85	84	8	10.53	35.98	
7	Tissue typing	5	15	10	6	7.20	3.17	

**Kruskal-Wallis test [H(df=6) 487.383, p<0.001]*

Table 8. Influence of send-out testing typing upon cost by laboratory category and screening category (n= 2986)

#	Send-out test laboratory category	< €100		> €100		Total	%	*p*-value
		n	%	n	%			
1	Immunochemistry	1490	49.9	42	1.4	1532	51.3	
2	Clinical chemistry	985	33	0	0	985	33.0	
3	Hormonology	255	8.5	0	0	255	8.5	
4	Tissue typing	15	0.5	0	0	15	0.5	<0.001*
5	Molecular biology	0	0	173	5.8	173	5.8	
6	Microbiology	0	0	15	0.5	15	0.5	
7	Histopathology	0	0	11	0.4	11	0.4	
	Total	2745	91.9	241	8.1	2986	100.0	
	Send-out test diagnostic category	**n**	**%**	**n**	**%**	**Total**	**%**	***p*-value**
1	Screening	1626	54.5	57	1.9	1683	56.3	
2	Confirmatory	574	19.2	184	6.2	758	25.4	<0.001**
3	Diagnostic	545	18.3	0	0	545	18.3	
	Total	2745	91.9	241	8.1	2986	100.0	

** Chi-square Test:[χ^2(df=6)=2435.45, p< 0.001]*
***Chi-square Test: [χ^2(df=2) = 365.84, p< 0.001]*

In Table 8, the association between send-out test laboratory category and cost category is analyzed. Cost significantly depends on laboratory test categorization [χ^2(df=6) = 2435.45, p< 0.001]. Likewise, cost significantly depends on diagnostic test category [χ^2(df=2) = 365.84, p< 0.001]. [In a Spearman's rho calculation, cost (as a continuous variable) strongly and significantly correlates with TAT (r = 0.77, p<0.001)].

4. DISCUSSION

Most laboratories are now struggling with a new financial sink, the spiraling volume and exponentially spiraling costs of send out testing. A large majority of that growth can be directly attributed to modern tests such as new molecular diagnostic techniques. The volume in some laboratories went from zero to five hundred in a few years. A good example of such growth is comparative genomic hybridization microarray (CGH array) testing, which costs $1,500 per test [11]. Because these tests are complex and frequently have patents (or proprietary algorithms; see later), most laboratories cannot currently and may never be able to perform them in-house. The present work creates a structured database about reference testing in AHAFH, analyzing its correlates and influence on the costs incurred to support the diagnostic and health evaluation efforts in the hospital. Such database has not been examined before. One of this work's strengths is that we utilize reputed reference laboratories in Europe, ensuring high validity and reliability of our database. Moreover, all eligible send-out requests have been included, and hence a high study power is assured. Such these strengths increase the study's precision and stability potential. Overall, the revealed findings provide evidence-based information about the utilization pattern of send-out testing in AHAFH. This information helps improve and evaluate such vital laboratory practice through a cost-effective send-out testing policy [12].

4.1 Send-out Testing Volume

The send-out testing rate (0.11%) of AHAFH the time of this study is quite modest. Some central laboratories achieve much greater figures. In their study to analyze reference laboratory testing of Massachusetts General Hospital, USA, MacMillan et al. [4] report that reference laboratory cost totaled 1.06% of the test volume in the hospital. In which case, reference testing in the US study is almost ten-times ours. The large difference between the two studies may partly be attributed to the inclusion of a significant number of new molecular and microbiological assays in the US study laboratory's menu. Otherwise, a sending out decision generally involves scientific aspects, as well as attitude toward the diagnostic approach of the health practitioners who initiate the test order. In essence, an optimum send-out decision depends on the strength of evidence between the disease and the test, as will be discussed soon. Laboratory managers and clinicians share the need to evaluate the use of each test based on the literature. Some tests have been obsolete, yet still being requested. The ordering pattern of physicians in each specialty lets us know what tests they are ordering and who the biggest users of these tests are. Accordingly, we would like to provide assistance, as needed, either supporting the use of the test based on the scientific evidence or discuss with them other options to the best interest of the patient's diagnosis. Some of these misused tests include LE cell test, Schilling test, Free T4 index, prostatic acid phosphatase and Bence Jones Proteins. These tests are deemed obsolete, according to the American Association of Clinical Chemistry, Clinical Laboratory News, December 2007, and as supported by the majority of laboratory directors' opinions [13]. Some even see that total amylase and total phenytoin are obsolete, too. Further, there is now a strong literature in support to say that the anti-single-stranded DNA is non-specific in patients with connective tissue diseases. Moreover, there is no CAP proficiency testing for this test [4].

4.2 Send-out Testing Utilization Attitude of AHAFH Physicians

In this study, we were able to measure the send-out testing requisition pattern of each of the hospital's departments. For instance, pediatricians are the most consumers of this service (37.7%), e.g., compared to internal medicine (7.4%). They are also the most users of immunochemistry testing (21.8%), including common internationally-used immunochemical (e.g., ELISA and immunochemistry assays), and were second in clinical chemistry testing (7%). Unsurprisingly, immunochemistry techniques have a special emphasis in the diagnosis of an array of childhood diseases, including IDs, gastro-intestinal bleedings, neurologic diseases, Hodgkin's lymphoma, and blood malignancies. Likewise, neonatologists tend to be high users of reference laboratory testing, e.g., second to pediatrics both in clinical chemistry and molecular biology testing. Obviously, tissue typing has almost always been mere rheumatology practice utility. With respect to the notable difference between AHAFH overall send-out test volume and counterparts elsewhere, several reasons could be examined. First, could be doctors' attitude to reference testing; why, when, and how to use. Second, the scientific and leadership support clinicians receive from the laboratory side. Some other conceptual trends and medical practice style of clinicians, as well as traits related to morbidity, demographics, epidemiology, and economic status of the community, play a role. The variation in morbidity and epidemiologic characteristics and disease burden in different geographical areas can cause variability in the laboratory diagnostic trends even in the one region. Particularly, our doctors' perspective of send-out testing obstacles, such as wait time or cost in comparison with other health institutions can be focus of future research. Third, the difference in the test coding system is a common cause for the variability in the send-out testing statistics. A coding system generally offers clinicians a uniform process for coding medical services that streamline reporting and increase accuracy and efficiency. For instance, for more than four decades, physicians in many health systems have relied on current procedures terminology (CPT) to communicate with colleagues, patients, hospitals, insurers and payers about the procedures they have performed [14]. Since no specific coding system has been yet standardized in AHAFH until the time of this study; a "head-to-head" comparison between our testing rates and other laboratories' needs special scrutiny.

4.3 Judging Send-out Testing Utilization Based on Test Results: Is There Misuse?

In the analysis, we meant to measure the impact of send-out tests typifying on the variation in test results; conclude prevalent pattern of testing result for each test category. This can measure

how justifiable send-out test utilization is. First, a negative result significantly outnumbers positive ones (39.9% vs. 25.5%). Specifically, negative immunochemistry reports remarkably dominate (66.3%). These tests are in common use locally and internationally [4] to rule in or rule out a myriad of ailments, common of which are auto-immune diseases. Symptoms of some inflammatory diseases often mimic auto-immune symptoms, especially if the same organ was affected, such as joint disease, neurological or gastrointestinal diseases, therefore, the use of a relatively low-cost immunochemistry test (<€100, 49.9% of the time) to preclude a serious auto-immune disease may be justified. As with immunochemistry, negative clinical chemistry reports are more than double of positive reports. The criticism here is that symptoms of diseases analyzed through clinical chemistry testing are more straightforward. Ailments such as those related to serum cupper metabolism, serum pyruvic acid, or metabolic diseases in children are examples. Therefore, justification of clinical chemistry testing by AHAFH physicians is compromised; misuse is likely. On the other hand, we can understand why our pediatricians are most users of tests such as immunochemistry, molecular biology, and hormonology, compared to other specialties. These tests reflect disorders that are more prevalent in children, such as inborn errors of metabolism, and congenital immune-compromising syndromes. Pediatricians suspect the presence of such syndromes; make clinical diagnosis based on defined congenital criteria and developmental derangements, and then move to investigation. Logically, a pediatrician would want to select the test most appropriate for ruling in the ailment in question. If failure of getting a test result in favor of the disorder significantly exceeds the success of getting a test result in favor of the disorder, as in our immunochemistry and molecular biology testing, then misuse is likely. On the other hand, the utilization pattern of clinical chemistry testing is more or less rational. For instance, recruitment clinic is the most user of this testing type, primarily to examine drug levels and substance abuse among volunteer cadets. This area of testing is crucial in deciding on physical fitness and eligibility for this group of recruits. A negative test finding in this domain is as important as a positive one, and either result has to be documented in the cadets' records. Thereby, clinical chemistry ordering trend in the hospital is not a misuse. Hormonology testing, too, is virtually pediatrics' utility (90.6%). Two third of hormonology results are distributed between low and high levels, while the rest have normal levels. The utilization trend in this domain is also justified. Regarding tissue typing, all 15 tests (14 of which are from the rheumatology unit), did not reveal the presence of the suspected HLA27 tissue type. The unit cost of HLA typing here (€67.53) is within the "<€100.00" cost group, (but still not cheap). Given the universally negative HLA typing reporting in 2011, judging whether misuse in this domain is a concern needs further discussion with AHAFH's physicians, led by the literature and best-practice guidelines. The nephrology testing pattern is more or less balanced. Renal biopsy is an invasive procedure, which needs special precautions and has its own risks [15]. Further, if enough medullary and cortical kidney tissues were not obtained, the specimen would be useless. Interestingly, all eleven renal tissue specimens sent out for testing showed expected pathological changes. Despite the high cost and the risk it poses, utilization of histopathology testing based on the currently used pattern can be deemed cost-effective. The situation of microbiology send-out testing in the hospital is less challenging, too. All requests were TB C/S. Usually, a tissue culture for *M.* TB species is requested to confirm active TB infection in a TB suspected patient. In which case, the patient passes first through a series of screening tests, including tuberculin skin test (TST) or interferon gamma release assay (IGRA) for TB. Positive results are followed up by chest X-ray to look for signs of active TB. If active TB disease is suspected, acid-fast bacilli test, including smears and cultures would be used to confirm the diagnosis, (and determine the drug susceptibility for the *M. TB)* [16]. So, all sent-out specimens for TB C/S reported positive, and microbiology utilization is not a concern.

4.4 Send-out Testing Costs

Cost is the prime outcome under investigation in this work. The total cost (€168,903.5) of reference laboratory testing represents 11.7% of the total laboratory tests cost in AHAFH in FY 2011. The unit cost per test is featured around €50 (*IQR=12)*, with a rather wide range (€12.20 - €383.00). However, the weight of expensive reference tests (>€100) is significantly less than that of less expensive (<€100) tests. The former totals only 8.1% - while the latter mounts up to 91.9% of the total send-out tests volume. High cost comes mainly from esoteric tests, such as, molecular biology, histopathology, and microbiology. These tests involve advanced

technologies, costly ingredients, and high operational and manpower costs, including skillful staff time and training, equipment and special setup. Highest among all is the cost of histopathology tests. Truly, pathological specimen examination requires most experienced and highly scientific calibers. A pathological report on a specimen from a deranged tissue could be the last possible step to rely on, in the pathway of examining serious conditions, such as focal glomerular sclerosis or in grading chronic diseases such as cancer lung [17], or chronic liver diseases [18]. Moreover, histopathology reporting may include recommendations for specific intervention. Therefore, those tests last moderately long until the report is released (TAT= 19 - 49 days).

In the MacMillan et al. [4] study, reference laboratory tests cost was 12.4% of the total test cost; very close to ours (11.7%). The average unit cost these tests in that study was reportedly 13 times greater than the average unit cost of all laboratory tests (in-house and send out tests). The average unit cost of reference tests in our study is €56.56 and the average unit cost of all laboratory tests is €0.40 [1443619.6 / 3675000]. Further calculation reveals that the unit cost of our send-out tests equals 164 times the unit cost of in-house tests (56.56 / 0.34). And this theoretically means that the cost of reference testing in our hospital is almost twelve-times greater than that reported by MacMillan et al (164 vs. 13). Thereby, if the estimated cost of introducing certain reference test systems would be offset within a reasonable break-even time interval by the saving from not sending these tests out, performing them in-house would be cost-effective. Funding options of the prospective test system need to be negotiated carefully, bearing in mind the need to pay off any loan premiums and debt services on time, alongside with the operational cost of the introduced tests. A multitude of extra benefits from the reference tests added to the laboratory's menu of high demand may also worth the investment, e.g., shortened TAT and building up skills of laboratory staff that can be passed to junior colleagues. Moreover, the added test services could be marketed out, upon the laboratory's discretion.

4.5 Turnaround Time Status

Turnaround time is the secondary outcome variable in this research. It is one of the most noticeable signs of laboratory service and is often used as a key performance indicator of laboratories' performance [19]. Clinicians desire a rapid, reliable and efficient service delivered at low cost [20]. Of these characteristics, timeliness is perhaps the most important to the clinician, who may be prepared to sacrifice analytical quality for faster TAT. This preference drives much of the proliferation of point of care (POC) testing seen today. Laboratorians may disagree with such priority, arguing that unless analytical quality can be achieved, none of the other characteristics matter [21]. Despite advances in analytical technology, transport systems and computerization, many laboratories have difficulties improving TAT. In this research, median TAT for send-out tests is 12 days and ranges between 2 days and 30 days. The longest median TAT was for histopathology (30 days) and molecular biology (26 days). Clinical chemistry and microbiology lie in the middle (15, 21 days, respectively). Tissue typing, hormonology, and immunochemistry tests had the least median TAT (6, 8, 9, respectively). As we can learn from the findings, a little number of immunochemistry reports (3 TNF tests and 6 interleukin beta tests), were delayed until 131 days. The vast majority of all 100 interleukin beta test reports (whether 6-beta or 1-beta) took 12 to 47 days. Likewise, TNF TAT ranged between 2 and 47 days for all requests, except the three 131 day incidents. This delay could be attributed to data entry errors or probably transportation disarrangement. Such logistics and data entry or release mishaps do occur in the send-out testing care. Send-out tests of long TAT usually involve meticulous immunological or biological techniques. Especially immunochemistry is the most demanded tests (51.3%) in AHAFH, the reason why they may be prioritized in any proposed plans to perform reference laboratory tests in-house. Since the utilization of reference tests targets selected tests mostly beyond the local laboratory's technical and staffing capacity, introducing any of these tests in one's local laboratory entails evaluating the potential financial benefits. Above all, it is hard to underestimate the importance of clinical laboratory test results. Nearly 80% of the physicians' medical decisions are based on information provided by laboratory reports [22]. The question always rises; *"is it wise to introduce the test in our laboratory or to continue sending it out to a reference laboratory?"* Kiechle [23] presents an important review, which provides guidance to help large hospitals managers in answering such critical send-out / in-house testing question. The study sets basis to forecast

in-house vs. send-out costs of a new test. For the sake of comparison, Kiechle, for instance indicates that the rate of sending out for bacterial meningitis C/S test accounts in a Memorial Healthcare System, South Broward County, Florida, USA 9622 tests a year. This number alone exceeds all our sending out test volume in AHAFH in one year. Interestingly, too, Kiechle classifies the send-out tests into laboratory test categories almost identically to ours. He focuses on important high demand and often costly tests which also require meticulous techniques, same as in our study, e.g., immunochemistry, molecular biology, and clinical chemistry. Further analysis of Kiechle data enabled us to conclude the median value of the cost of these test categories, corrected to 2011 money value (e.g., inflation rate 3.5% compounded for 7 years from 2004 – 2011; average dollar-Euro transfer rate in 2011 = 0.74). The median costs were consistently higher in our study than Kiechle's rates as follows: molecular biology (€179 vs. €70), clinical chemistry (€76 vs. €70). (Particularly hepatitis-C genotype testing cost is 190.59 vs. 94.00). More importantly is the agreement in the need to incorporate these send-out test classes while planning for bringing some stressing tests in-house to save money and time, and hence improve laboratory performance quality.

4.6 Recommendations for Improving Send-out Testing Service at AHAFH

First, AHAFH laboratory management needs to recognize all inappropriately ordered tests and the process of working with the medical staff to improve send-out test utilization practice. This is related to clinicians' behavioral, knowledge, and attitudinal tendencies that need to be identified and improved. Some assumptions have been postulated with this respect, such as that *"doctors are comfortable ordering most tests."* It has been also thought that *"experienced physicians need less help in ordering and interpreting sophisticated tests compared to younger colleagues."* In fact, none of these assumptions is absolutely true. Naturally, all clinicians have gaps in their knowledge; factoring the growing number and the complexity of such tests. Another assumption is that *"physicians will get upset if they are offered help by the laboratory specialist,"* and so on. But this is not true either. If approached as a respected colleague, most physicians welcome professional help. The clinicians' attitude to laboratory tests utilization has been categorized based on the degree of "innovativeness" [13]. Thereby, physicians may either be "innovators", "early adopters", or "conservatives" (traditionalists). The innovators are going to be at the leading edge of advancing tests. Early adopters pick up these tests; otherwise, most will be somewhere in-between. What we need to be cognizant of is to get the support of the innovators and early adopters. Also we need to be aware of the traditionalists among our staff and ask them why they may oppose implementation of a new test. Physicians should be updated of obsolete tests (e.g., single stranded DNA and T3 uptake) to avoid requesting them. On the other hand, they should be informed that tests, such as sweat chloride are not obsolete [24]. Ultimately, should the overall volume of send-out testing – or the frequency of certain tests - be a concern for AHAFH, we have to ask ourselves how often it should be ordered in a hospitalized patient and whether this recommendation based on high level literature-supported evidence. Sometimes, if we just get our physicians to think about their ordering pattern without even doing anything except asking the question, we can get them to think about the frequency of testing. Physicians may also be discussed on their understanding of the hierarchy of evidence for disease diagnosis. Although isolation of the causative organism stands as "most reliable" method to confirm the diagnosis of most IDs, this is not the case in a number of infections where growing the organism on media is associated with a validity and reliability concern. For instance, confirming the clinical diagnosis of pertussis, (which is based primarily on having a high clinical index of suspicion for the infection) by laboratory testing depends on RT-PCR test rather than culture or direct fluorescent antibody (DFA) testing. Culture and DFA are limited by low sensitivity, rendering DNA amplification and, in selected circumstances, serology the tests of choice [25]. Irrespective of whether the laboratory test requisition system is on paper or electronic, esoteric tests, such as neurogenetic tests, need to be eliminated. A neuroendocrinal test like pancreatic polypeptide to screen for pancreatic tumors is not useful if the prevalence of pancreatic cancer in a particular population of patients is not very high. The use of algorithms to assist in rationalizing test selection is highly recommended. They provide guidance and reduce unnecessary testing, and help systematize and standardize the test selection process through a clearly structured stepwise framework. A good example is pernicious anemia testing cascade developed by Mayo Clinic

Laboratories. (More than 80 algorithm testing models are available) [26] [It begins with testing vitamin B12, where no further testing is performed where there is intrinsic factor blocking antibody (can be positive, indeterminate, or negative), so we decide whether gastrin is performed].

4.7 Setting up Clinical Practice Committee to Improve Test Utilization

In order to further improve send-out test utilization in AHAFH, we might consider setting up a "clinical practice committee" to create among laboratory professionals the culture of having general oversight of the patient care actions in laboratory medicine and try to look at promotion of best practice in a fiscally responsible way. Several successful examples of similar committees are available at leading health institutions [27]. Laboratory managers also want to make sure their decisions are driven by the literature in evidence-based laboratory medicine and pathology. For example, if we have several breast tumor markers and we want to decide which one we would like to standardize in our practice, this would be a perfect example to take to the clinical practice committee. If we want to eliminate some test choices, e.g., single-stranded DNA, this is a good place to refer to, examine the literature and to confidently remove that test and to introduce a better alternative. In the matter of fact, coping with continuous laboratory medicine advances should associate any actions taken to remedy the send-out testing process. The issue is that laboratory medicine superbly sees a state of dynamic advance which is changing the face of medical practice in an unprecedented fast pace. A countless number of new tests are on the horizon and these may currently be underutilized, such as genomic and proteomic markers, rapid PCR and other molecular testing in microbiology, and new biomarker panels for cardiovascular disease and oncology. Perhaps, these tests are going to become a mainstream, soon. Nonetheless, physicians should not rush in their test selection, just because the test is a new advance. On the other hand, they should not underestimate newly advanced techniques, only adhering to old or obsolete tests just because this what they only feel comfortable with or the best they know. The decision about the most appropriate test selection should be balanced and based on accurate scientific and professional bases. Clinicians should be able to ask the right question regarding the diagnostic line they want to follow, and the test which provides an actual clue to disease diagnosis, all under an evidence-based umbrella of the literature, best practice, and the use of laboratory-diagnosis algorithms.

After it has been made easy that we can determine in our own area what send-out tests are over-utilized, further challenge remains, which involves the way we proceed in approaching physician colleagues, let them share same vision through rapport and a healthy communication climate. Subsequently, a better chance of improving laboratory utilization would be sustained. Informal medical staff leaders should be given a special emphasis in this process. They would be the innovators and early adopters and recognized experts. For instance, if we are going to change our mucopolysaccharides testing policy, one of the first things physicians will ask: *"what do expert hematologists believe is the current practice?"* On our part, key medical staff users of a particular test should be convinced first. In essence, obtained quality data persuade; and emotions motivate, and subsequently physicians can easily come to their own conclusions. This leadership technique has been applied with a remarkable success in Mayo Clinic, e.g., by transfusion medicine for use of blood and blood products, and changed from B-type natriuretic peptide (BNP) or N-terminal pro b-type natriuretic peptide (NT-proBNP) in evaluating the severity of heart failure [13]. Both laboratory mangers and clinicians want to continually scrutinize the ongoing test ordering pattern and order sets. There may be some details that are built into the laboratory's order sets and the physicians' standing orders that may no longer be clinically indicated. Let us remember, the laboratory is no longer a "revenue center"; in many ways it is a "cost center", so we have to work with our physicians to assure the right send-out test is ordered on the right patient at the right time and for the right indication. Proposing guidelines on test requisitions and computerized reminders regarding timelines provide guidance and often help the change clinicians' practice patterns [28]. Yet, next should come developing "utilization report cards" and changes to the manual requisition system. [In some institutions, computerized physician order entry (CPOE)-physician order entry dataset may be in use]. Those changes can guide toward algorithms and judicious use of tests. The obtained utilization report cards are further supported with peer review. This is based on data mining in our own system and any clinicians as well as pathologists

and scientists in the same room to do some peer review. Higher level approval may be required for more esoteric tests. Finally, the strictest guide is utilization report cards with leadership review and incentives or penalties to encourage that behavior. Some academic centers have actually gone as far as forbidding some tests. Having a green, yellow, and red pattern so that everyone can order green tests, only a few can order yellow, and red are completely abandoned unless there is explicit permission to order those tests. The suffering from send-out testing load and costs might not yet be as worrying in our hospital as in other institutions elsewhere [4,23]. However, waiting as long as 47 days, and often 131 days, jeopardizes the promptness of diagnostic decisions in many health service areas in the hospital is uncomfortable. In either case, it is time to start putting a degree of control on send-out tests requisition [29], meanwhile to not undermine the physicians' right to seek opportunities to provide the best medical intervention to their patients. Moreover, setting cap on sending tests out, e.g., €50.00 (median cost in FY2011) is a convenient intervention to exercise wise control on send-out testing in AHAFH. This limit should be the "fair value", above which any send-out request should be rationalized. For instance, a "send-out request form" should be filled up and attached with the electronic test order. The form contains all necessary fields, including provisional diagnosis, disease severity and grading data, diagnostic importance of the test, as well as demographic data of the patient. The laboratory manager will then measure this information according to updated evidences in support of the request, if needed, and discuss their search findings with the physician in charge.

In cases of evolving economic hardship in the presence of a sustained high disease prevalence, some alternative advanced procedures that are quick and do not need skillful staff and that can be as valid and reliable as standard reference tests are now available. This situation is particularly important in HIV diagnosis. Still, the gold standard test for HIV diagnosis remains the ELISA antibody test (performed in duplicate) and followed by confirmation with a Western blot [30]. Rapid HIV testing (detects HIV-1 and 2) can now be performed on a sample of whole blood, plasma, or oral mucosal transudate (using the OraQuick Advance Rapid HIV Antibody Test; OraSure Technologies Inc., Bethlehem). Although this test has become a commonly use point of care test, it, like all rapid tests, remains only a screening test that requires follow-up Western blot confirmation when results are reactive. (Reported clusters of high false-positive rates have demonstrated the potential for poor positive predictive value of such screening tests in low-prevalence settings, and emphasized the need to clearly label test results as preliminary) [31]. On the other hand, since the current HIV testing strategy in resource-limited settings is rapid tests or dual standard ELISA tests (in series or in parallel) from different manufacturers [32], creative strategies have been developed to render rapid HIV testing as effectively reliable as a confirmatory test, since veni-puncture samples for Western blot are often inaccessible. In Botswana, testers begin with parallel rapid tests ("UniGold Recombigen HIV", Trinity Biotech, Bray, Ireland, and "Determine HIV-1 and 2", Abbott Diagnostics, Abbott Park, IL). If the results of these tests are discordant, they are both repeated. If they remain discordant, the OraQuick test is used to make the final determination [33]. According to a 2004 report from the Joint United Nations Program on HIV/AIDS and the WHO, such combinations provide the same reliability as an ELISA supplemented with Western blot, and do so at much lower cost [34]. With the recent availability of waived rapid HIV testing, Aspirus Keweenaw Hospital (Laurium, Michigan, USAI) [35] evaluated bringing this test in-house. Technically, interested laboratories would like to introduce this test without the need to install permanent equipment. The cost of traditional send-out HIV rapid test is $31.40, compared to an in-house around $14.5. The new rapid test result is ready in only fifteen minutes. This time-saving is crucial in case a healthcare worker (HCW) gets exposed to a needle-stick injury. The new test allows correct treatment of the exposed HCW by not placing her or him on post-exposure prophylaxis (PEP) for treatment of HIV, and reducing the risk of toxic PEP [35].

In this work, every possible effort to deploy adequate resources and ensure circumstances most appropriate for revealing required information about send-out testing in AHAFH have been done. Yet, few limitations had to be encountered. It would have been interesting to compare AHAFH send-out testing experience with the local situation in KSA. However, the scarcity, if any, of such studies in Saudi Arabia had kept us from covering this angle. Also, conducting a detailed comparative economic evaluation of our reference testing practice with leading healthcare systems, e.g., in Europe, was

confined by the difference in the economic foundations of health care delivery in Saudi Arabia and those systems. Both, the military and civil healthcare services in Saudi Arabia are totally free of charge for all Saudi citizens, and as of the time of this research, no health insurance or reimbursement issues are in the mindset of the healthcare policy in the country. In contrast, health insurance, payment options, and the presence of a cap on offered health benefits, all shape the Western health systems' access patter, and hence guard the comparison. Otherwise, the study has other strengths, especially furnishing full send-out testing dataset for current and future planning and service evaluation. Also, most important factors surrounding the distribution and determinants of such vital sector of laboratory service in Saudi Arabia have been addressed and analyzed.

5. CONCLUSION

In conclusion send-out tests involve sophisticated techniques and setup not usually available for most standard laboratories. The cost of having these tests done at reference laboratories is usually high. The utilization of these tests is rising steadily, and the subsequent pressure on central laboratory budgets is growing. Wait time until test results are received, logistics line, and data handling errors during the pre-analytic or post-analytic phases, all can jeopardize a timely and accurate patient diagnosis and monitoring. In AHAFH, send-out testing comprises a vital component of the laboratory service. Although it represents a small percentage of the total test volume, send-out testing accounts for a disproportionate percentage of the laboratory expenses. In order to meet the expected growth of the burden of these tests, AHAFH would rather adopt creative strategies to face future challenges. One approach is to develop a new electronic lab requesting documentary system and forms with actual cost and financial data enclosed. Findings from this study provide database that may well support these strategies. The hospital can use this data to develop a cost-effective send-out testing policy, including adjusted budgeting and proper resource utilization. A future cost-effectiveness analysis study, e.g., comparing send-out testing cost over a three-year period, will help in making an informed decision on whether to continue sending those tests out or introducing them in-house.

ACKNOWLEDGEMENTS

We wish to thank Dr. Mohamed Bamaga, PhD, former head of Al- Hada Laboratory for his support and follow up of this work's development. We are deeply indebted to Mrs. Anita R., senior laboratory technician and send-out data coordinator for her assistance in data preparation until a preliminary data was made available for this research.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/16806