Assessing CD4 rejections across a national laboratory service for 2018 in South Africa: highlighting the importance of adherence to national handbook guidelines

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Abstract

The National Health Laboratory Service as the preferred pathology service provider for the public health sector in South Africa, developed a national laboratory handbook to improve the clinic-laboratory-interface. A separate primary health care laboratory handbook was developed as part of the ideal clinic initiative by the National Department of Health. This study aimed to assess adherence to these guidelines using CD4 rejections the indicator. The retrospective cross-sectional study design was used to analyse national laboratory data for the period from January to December 2019. Data were analysed using SAS 9.4. Lookup tables assigned the origin (health facility/laboratory), rejection reason, and sub-reason based on the populated rejection description that was captured in the laboratory information system. The rejection rate [RR = (rejections/total volume) ´ 100] was reported at the national, provincial and district levels. There were 85,378 rejections reported for 2,844,242 tests (RR 3.0%). Data was reported for 4136 health facilities across nine provinces. The RR was higher for an origin defined as health facility (2.9%) than laboratories (0.1%). The most common rejection reason was unsuitable specimen received (RR=2.3%), representing 75% of all rejections. This rejection criteria included using the incorrect anticoagulant, clotted sample and haemolysis. The provincial RR ranged from 2.2% to 4.0%. Three districts had an elevated RR ≥6% (organisational cut-off set at RR ≤5%). This study demonstrated the value of laboratory data to assess specimen rejections and identify causes to facilitate targeted training.

Introduction

South Africa is one of many countries implementing initiatives to achieve universal health coverage (UHC).[1] Under UHC, individuals and communities should receive quality health care services with no financial hardship.[1] UHC would facilitate access for all individuals to health care services to address the most significant causes of disease and death.[1] The key tenets of UHC are improving health service coverage and health outcomes, of which the provision of quality primary health care (PHC) services is the cornerstone.[1] South Africa has multiple levels of health care services that are managed at the health- district level. Primary healthcare (PHC) services are offered by clinics and community healthcare centres (CHC). Hospital services are offered at the district, regional, tertiary and academic levels.

PHC services have adopted the ideal clinic initiative (ICI) to improve service delivery as a mechanism to realise National Health Insurance (NHI) in South Africa.[2,3] This was developed to address the historical deficiencies in the quality of PHC services.[2] An 'Ideal Clinic' has been defined as having good infrastructure, adequate staffing, adequate medicines and supplies, good administrative processes, ample bulk supplies to ensure continuous service delivery (clinical policies, protocols and guidelines) as well as partner and stakeholder support.[2] Progress made towards this initiative is monitored using the ideal clinic dashboard that assessed ten components: (i) administration, (ii) integrated clinical services management, (iii) medicines, supplies and services, (iv) human resources for health, (v) support services, (vi) infrastructure, (vii) health information management, (viii) communication, (ix) district health system support and (x) implementing partners and stakeholders.[2] The clinic-laboratory interface (CLI) is measured using component three (Medicines, Supplies and Services) and sub-component 13 (Management of Laboratory Services).[2] For the CLI, the following indicators are used: (i) laboratory handbook availability (ii) specimen collection material availability, (iii) application of standard operating procedures for collection, packaging, storage and transportation of samples according to the laboratory handbook and (iv) receipt of laboratory results from the within the specified turnaround times.[4]

Two laboratory handbooks have been developed to facilitate the dissemination of information and generating standard operating procedures to ensure that the CLI is optimised, *i.e.* national laboratory handbook for all levels of care and PHC laboratory handbook (PHCLH).[5,6] Both laboratory handbooks guide health care workers on the standard processes to follow to ensure timely delivery of a quality patient result. This includes instructions on the completion of the request form, which collection materials are appropriate for a specific test and the correct method for sample collection.[5,6]

It was envisaged that the implementation of these user handbooks, would decrease rejections (noted with previous iterations of the laboratory handbooks) to

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an acceptable level of <5%. The PHCLH was developed to provide guidance on all aspects of the CLI process and includes additional standard operating procedures for specimen packaging, storage, courier collection, management of laboratory results, ordering of specimen collection materials and accessing additional information.[5] The procedures outlined within the PHCLH directs what happens with samples after collection and upon receipt at the laboratory receiving office.[5] The handbook also indicates that specimens may be rejected by the laboratory if essential criteria are not met *e.g.* submitted with the inappropriate anticoagulant.[5,6]

Rejected samples can lead to several health systems challenges. Patients may have to return to the health facility for another sample to be collected, incurring personal costs as well as inconvenience. Rejected samples can cause laboratories to incur losses for sample collection materials and analytical processing. Similarly, health facility can incur losses due to staff time allocated to the consultation and sample collection. Therefore, pre-analytical processes that includes sample collection, sample handling, transportation to the laboratory and procedures followed at the receiving laboratory, are crucial in ensuring that specimens progress to the analytical phase (testing) efficiently for processing.[5,6]

The laboratory information system (LIS) is used to record the receipt of all samples, and if necessary, with reasons for rejecting the test. An analysis of these varying rejection justifications can provide a useful mechanism to understand the underlying causes. The number of rejections collated by rejection type offers insight into whether the laboratory handbook procedures are both understood and followed, *i.e.* adherence. There is limited local data on the rate of rejections using public sector laboratory data.

This study aimed to assess CD4 rejections for public sector facilities in South Africa as an indicator of adherence to the described guidelines. The rejections were quantified by using the rejection description captured in the LIS. Furthermore, a bottom-up costing analysis was undertaken to assess the financial impact of rejections on specimen collection materials.

Materials and Methods

The retrospective, cross-sectional study design was used to analyse public sector CD4 annual laboratory rejections data for the 2018 calendar year (January to December), extracted from the Corporate Data Warehouse (CDW). This included data from all public sector hospitals and PHC services that sent a CD4 sample to a National Health Laboratory Service (NHLS) laboratory that was rejected. The NHLS serves 80% of the population in South Africa. Convenience sampling was used for all health facilities that utilise the NHLS services across South Africa. Our inclusion criteria included all CD4 requests submitted to an NHLS laboratory that was rejected in the LIS. All electronic gatekeeping (eGK) rejections were excluded.

The rejection data was extracted from the CDW as password protected data extract with the following variables: i) episode number, ii) date rejected, iii) facility description, iv) province, v) health district, vi) rejection code, *e.g.* 'UCLT' and vii) rejection description, *e.g.* 'UNSUIT: CLOTTED'. The province and health district are populated in the CDW based on the health facility. Data was extracted for all nine provinces and fifty-two health districts.

On first review the rejection description data was cluttered with many different rejection descriptions reported in the extract, *e.g.* 'unsuitable – clotted', 'unsuitable – fibrin clots','EDTA clotted'. To facilitate a more logical reporting of the rejection description, lookup tables were created to assemble and merge variations of similar individual rejection descriptions into broader logical groups, which were then reflected as a single unifying rejection reason.

Microsoft Excel (Redmond, CA, USA) was used to prepare the lookup table.[7] For each unique rejection description, the origin of the rejection, the rejection reason and sub-reason were assigned, *e.g.* 'Health Facility', 'INVALID: HAEMOLYSIS' was coded as 'Unsuitable specimen received' and 'Haemolysis' respectively. The rejection lookup table coding was reviewed and validated by a senior pathologist and senior medical scientist. With the grouping in place, a considerably smaller number of rejection reasons were reported facilitating rapid interpretation and reporting of national rejections data. The lookup table offer high levels of validity and reliability as the rejection code is matched to the lookup table only where an exact match is found using referential integrity.[8] Therefore, this approach is very reproducible in a relational database environment using a primary and foreign key. Microsoft Access was used to create a left outer join between the rejection data extract and the developed lookup table. The combination of the lookup table and rejection extract made it possible to combine multiple variations of rejection descriptions reported for an incorrect anticoagulant to be collated into a single rejection reason labelled as 'incorrect anticoagulant'.

SAS 9.4 was used to analyse the data joined using Microsoft Access (Cary, NC, USA).[9] The rejection rate (RR) was calculated as: RR = (rejections/total volume) ´ 100. National CD4 test volumes were extracted from the CDW at the national, provincial and health district levels. The total number of rejections and the RR was reported by rejection reason and origin. For an unsuitable rejection reason, the distribution of the sub-reasons was depicted as a pie-chart. For the provincial analysis, a bar chart was used to report the number of rejections by rejection reason, with the RR reported on the secondary y-axis (excludes samples where the province was not populated). The RR was reported by district and categorised as follows: i) <=2%; ii) >2.0-3.0%; iii) >3.0-4.0%; iv) >4.0-5.0%; and v) >5.0-6.0%

A bottom-up costing approach was used to assess the specimen collection material costs attributed to rejections. The labour costs at both the laboratory and health care facility, as well as possible patient costs are not reported. Costs for sample collection tubes were obtained from supplier quotations in Rands (ZAR) and converted to USD. The cost-per-rejected-test details are reported as a table and were used to calculate annual rejection costs.

Results

Analysis of national rejections

There were 85,378 rejections reported over and above a further 2,844,242 CD4 samples received at the laboratories of the NHLS in 2018 (RR: 3.0%). Data is reported for rejections for 4 136 health facilities. Of these, 81,986 rejections were attributable to a health facility (2.9%) compared to 3392 (0.1%) for a laboratory-based origin (Table 1). The most common rejection reason was 'unsuitable specimen' (n=64,232, RR=2.3%), representing 75% of all rejections. These included the following rejection descriptions: i) incorrect anticoagulant (non-EDTA), ii) sample clotted, iii) no specimen received, iv) EDTA sample contains less than 2 ml (insufficient), v) sample haemolysed, vi) specimen container not labelled, vii) haemolysis, viii sampling leaking and/or tube broken, ix) unsuitable (may include non-EDTA samples), x) specimen container empty, xi) expired vacutainer, xii) lipaemia, xiii) specimen container broken and xiv) submitted in a clotted tube (EDTA required) (Figure 1). This was followed by the rejec-

tion reason 'requires a separate specimen' (where a single sample was submitted, but at least two tests were ordered such as CD4 and HIV viral load) that comprised 0.2% of rejections. Similarly, the 'request form incomplete' rejection reason was noted for 0.2% of samples and comprised of the following rejection descriptions: i) 'Info does not match', ii) no request form received, iii) no test set requested, iv) not done: no age/dob, v) not done: no collection date, vi) not done: no collection date or time, vii) not done: no facility name, viii) not done: no gender indicated, ix) not done: no hcw name/number, x) not done: no health care worker signature, xi) not done: no patient id, xii) not done: no patient name/surname, xiii) not done: no patient number, xiv) not done: no ward/clinic and xv) withdrawn: patient id in doubt.

Analysis of the rejection sub-reason for an unsuitable specimen

Within the category of 'unsuitable specimen', the top three sub-reasons were as follows: i) 'incorrect anticoagulant' (*e.g.* a CD4 test ordered but submitted in the inappropriate anticoagulant (33%)), ii) 'sample clotted' (submitted in an EDTA anticoagulant with insufficient mixing (31%)) and iii) 'no specimen received' [a request form was submitted without a sample (20%)]. The remaining sub-reasons, contributing a further 15.0% of rejections (Figure 1).

Provincial analysis of rejections

The provincial RR ranged from 2.2% to 4.0%. Similar to the national outcomes reported above, 'unsuitable specimen' was the most common reason for sample rejection across all nine provinces and ranged from 65% to 85% (Figure 2). 'Requiring a separate specimen' was more frequently noted in two provinces where 2 789 and 2 296 rejections were documented (13% and 11%, respectively). Coincidently, these were also the two provinces with the highest burden of advanced HIV disease and highest number of CD4 tests ordered (data not shown, but reported elsewhere).[10] The reason assigned as 'request form poorly completed' was reported for 11% of rejections in one of these provinces (n=2443).

District analysis of rejections

At the district level, there was a wider variation of the RR, ranging from 1.4% to 5.4% (data not shown). A ≤2% RR was reported for 10/52 districts (19%). Similarly, an RR of >2.0-3.0%, >3.0-4.0% and >4.0-5.0% was reported for 15 (29%), 19 (37%) and 5 districts (10%) respectively. There were three districts with an RR >5.0%.

Table 1. Analysis of the percentage of CD4 samples rejection in 2018 across South Africa by rejection reason and origin.

Category	Total rejections, n (%)	Rejection rate (%)
Overall	85,378	3.0
Rejection reason		
Unsuitable specimen received	64,232 (75)	2.3
Require a separate specimen	6658 (8)	0.2
Request form poorly completed	4359 (5)	0.2
Cancelled by the laboratory, duplicate request	4065 (5)	0.1
Laboratory error	3392 (4)	0.1
Too old to process	2472 (3)	0.1
Rejection origin		
Health facility	81,986 (96)	2.9
Laboratory	3,392 (4)	0.1

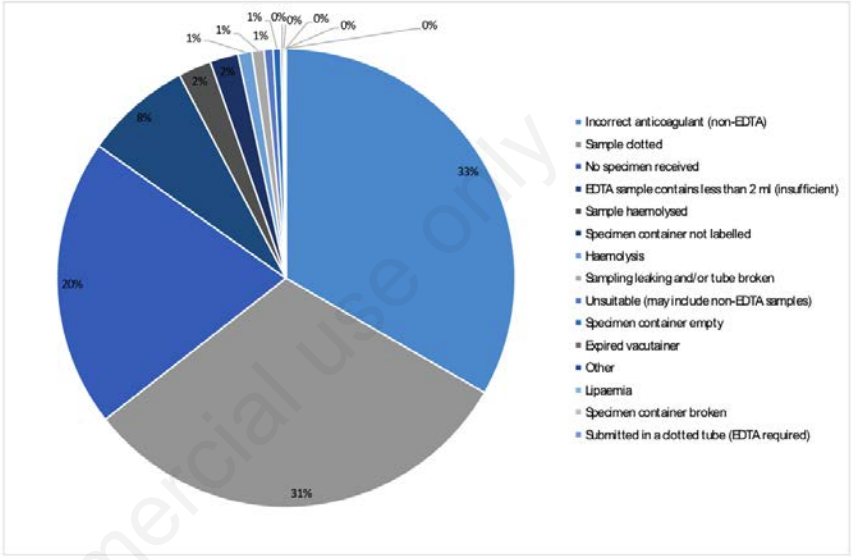

Figure 1. Pie chart indicating the percentage of samples by rejection sub-reason for an unsuitable specimen received a reason for CD4 testing in the 2018 calendar year across South Africa.

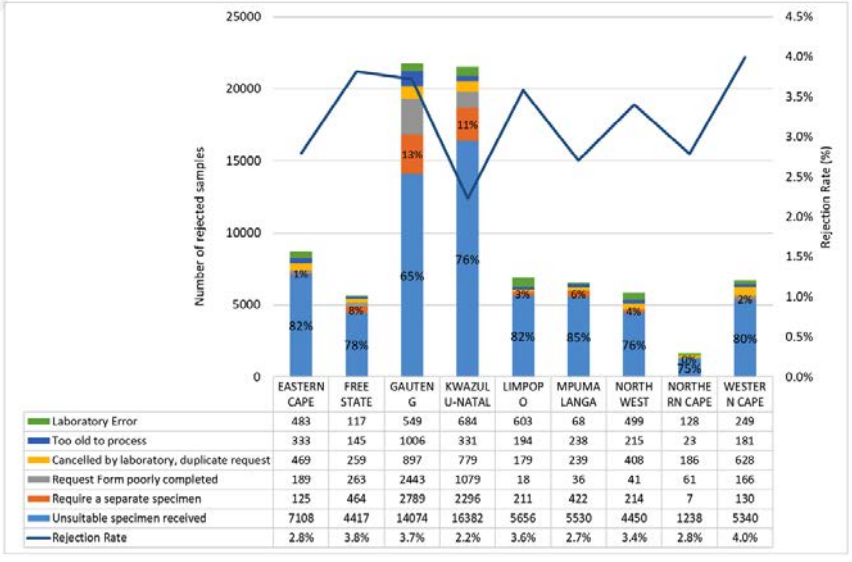

Figure 2. Bar chart indicating the number of rejections by rejection reason with a health facility origin for CD4 testing in 2018 in South Africa. The overall rejection rate is reported as a line chart.

Table 2. Bottom-up costing approach to assess the cost per result for specimen collection materials incurred for each rejection.

Item	Unit cost (ZAR)	% Unit Cost	Annual Cost (ZAR)	Annual Cost (USD)
Vacutainer tubes (EDTA)	0.71	18	60,643.99	4,261.70
Disposable gloves	0.53	14	45,258.88	3,180.53
Needle (18 g)	0.76	19	64,929.97	4,562.89
Laboratory request form	0.75	19	64,306.28	4,519.06
Specimen plastic bag	1.15	29	98,174.03	6,899.09
Total	3.90	100	333,313.15	23,423.27

Assessing the specimen collection costs for rejections

The cost of CD4 specimen collection materials for a rejection was calculated at R3.90 ($0.27) (Table 2). The specimen plastic bag contributed 29% of the cost per rejected sample. The needle and request form both contributed 19% followed by test tubes at 18% of the cost per rejected sample. An annual cost of R333,313 ($23,423.27) was reported for samples rejected in 2018.

Discussion

This study aimed to assess CD4 rejections for public sector facilities in South Africa as an indicator of adherence to the described guidelines. In particular, the RR could be used to assess pre-analytical conformance to national laboratory handbook standard operating procedures.

In this study, a national RR of 3% was reported that is within the organisational cut-off of ≤5%. There is limited data on what is an appropriate RR for CD4 testing in low and middle-income countries (LMIC). Certainly, the national RR reported is much lower than earlier reported RR for early infant diagnosis (EID).[11] At the national level, over two thirds of rejections were due to the receipt of an unsuitable specimen. When this rejection reason was analysed, the most common sub-reasons were an incorrect anticoagulant used, submitted a clotted sample or insufficient blood drawn. At the provincial level, the RR was as high as 4% that is still within the 5% cut-off. However, in keeping with national data, an unsuitable specimen was also the most predominant rejection reason. An RR of ≥5% was reported for only 3/52 districts (5.8%).

These findings indicate that despite the availability of laboratory handbooks with detailed standard operating procedures, the most common reason for CD4 rejections was an unsuitable specimen. A local study has reported that poor adherence by health care providers to follow instructions and procedures for drawing pathology samples contributed to a sub-optimal and ineffective CLI.[12] Clearly, these challenges still persist despite the implementation of the laboratory handbooks and the use of cascaded training to all health facilities.[6,13] This emphasises that in addition to laboratory handbooks, regular interventions are required to reduce rejections.

A key challenge with rejections is that patients do not receive their CD4 count resulting in a missed diagnostic opportunity. In addition, there are other consequences for the health care system. The patient needs to return to the health facility to collect another specimen resulting in delayed care, additional clinic visits and unnecessary travel costs. This could have been avoided by using the laboratory handbooks to collect the correct specimen at the original visit.

In addition to missed diagnostic opportunities, rejected samples also result in utilisation of health care resources without a clinical intervention. For specimen collection materials, a cost of $0.27 was reported per CD4 rejection. Across the public sector, an annual cost of $23,423 was reported. This indicates that rejections results in substantial wastage of specimen collection materials. With the inclusion of the labour costs of the health care worker, it is estimated that the annual cost could be as high as $54k. These costs would be much higher if additional costs for patient time and transportation were considered.

One possible explanation for the high rate of unsuitable specimens could be the heavy workload at public sector health facilities. Wilcox et al reported that South Africa, with a population of 51 million people in 2010, had an average of 6 health care workers (doctors, nurses and midwives) per 1000 population.[14] In comparison, the World Health Organisation (WHO) standard for severe health care worker shortage is 2.28.[14] This indicates that health care worker workload/shortage is not able to explain the high rate of unsuitable specimens.

Conclusions

This study has demonstrated that routinely collected laboratory data could be used to collate the underlying reasons for sample rejections. The identification of geographical areas with higher rejection rates can further facilitate targeted training to promote adherence to prescribed standard operating procedures. The approaches demonstrated for CD4 rejections data can be extended for a wider repertoire of pathology tests. The data generated in the LIS for rejections could be used to develop interactive dashboards to identify areas with high RR as depicted in this study. As the LIS data is available at the health facility level, it would be possible to identify hot spots for targeted interventions. In addition, innovative mechanisms are needed to integrate specimen collection training into existing programs offered in the public sector, by partners and other organisations.

Limitations

The study used predominantly laboratory data to assess CD4 rejections across the NHLS. Some samples may not have been rejected by the laboratory resulting in a falsely lower RR. The study was not able to assign a breakdown of the unsuitability of rejected test requests.

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