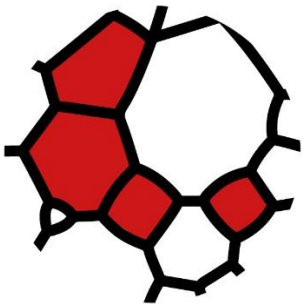


MeSH Consortium

Measurement & Surveillance of HIV Epidemics

A pilot intervention to digitise point of care HIV test results in the Western Cape

Contents

Introduction

Point of care testing (POCT) in healthcare is laboratory testing that is conducted close to the patient or site where clinical care is delivered, such as hospital wards or clinical consultation rooms(1). The advantages of POCT are well-known, notably the rapid turnaround time for obtaining test results which may directly influence clinical decision-making and management(1). In low-and-middle income countries (LMIC), where access to healthcare is often limited, POCT improves access to healthcare by reducing waiting times for test results and facilitating timely management and/or linkage to care and referral(1)(2). Despite these advantages, major challenges of POCT relate to quality assurance, particularly since testing is usually performed by non-laboratory trained staff (1).

Currently in South Africa, the National Health Laboratory Services (NHLS) provides laboratory services to the public health sector. The NHLS has a remarkable national laboratory information system (LIS) in which all laboratory test results performed anywhere in the country in the public sector, are available on a central LIS, and are a key component of surveillance activities. Robust health information systems can further contribute to improving linkage to disease-specific care through surveillance. POCT is, however, largely facility-managed and does not form part of the LIS. POCT in the public health sector includes tests for HIV screening and diagnosis, tuberculosis screening and diagnosis, syphilis diagnosis, blood glucose, haemoglobin, blood group, urinalysis, blood gas and others. With the current move towards increased POCT, the lack of integration of POCT results within the LIS may hamper laboratory-based disease surveillance as well as limit information available to clinicians when evaluating previous lab investigations for clinical decision-making. The lack of POCT results within the information system, may also lead to unnecessary repeat testing incurring increased costs and patient discomfort. Although various advanced POCT devices are available which have the functionality to capture POCT results and patient information directly into electronic information systems(1), these devices are not widely used in the South African public health sector and may require significant resource and training investment before wide-scale implementation.

In the absence of POCT devices with connectivity to health information systems, digitisation of POCT results from paper-based patient records may be the most feasible method for integration of POCT results within the LIS and broader health information system. A pilot systems intervention was conducted in a primary level facility in the Western Cape in which POC HIV test results were digitised and entered into the LIS and consolidated within the broader health information system. Despite the many advantages of enriching the health information system with

POCT data, numerous challenges were encountered during the implementation of this information system strengthening intervention. This report describes the implementation of this health systems strengthening intervention and findings in detail for further consideration of feasible methods of implementation of POCT data integration in to the health information system.

Background

Health Information System

The public health sector in the Western Cape comprises various levels of care from primary level facilities, close to the local community, to more specialised services at tertiary level facilities. Primary level facilities face many challenges common to LMIC such as high burden of disease, large patient numbers, staff shortages and subsequent increased staff workload and limited resources. Health information systems at primary level utilise a combination of paper-based and electronic systems. All patients within the Western Cape are provided with a computer-generated unique patient folder number, utilised across the public health platform in the province. Patient stickers containing the folder number and other identifying data are printed and placed in patient folders on arrival at the reception of most health facilities. These stickers are placed on all clinical stationery pertaining to the patient. In order to increase access to HIV testing, patients presenting to health facilities solely for HIV testing are permitted to consult an HIV counsellor directly, without obtaining a folder and patient stickers at the facility reception. Patient identifying information is hand-written by HIV counsellors on the POCT HIV stationery. This reduces waiting times at health facilities for those wanting to test for HIV, thus improving access to HIV testing. Only patients who subsequently test HIV positive are referred to reception to obtain a folder for further clinical consultation and management. Clinical staff largely make use of paper-based systems for medical records, POCT, prescription of medication and other clinical tasks. Aggregate data from administrative and clinical areas are entered manually into paper-based registers and submitted for electronic entry into the provincial information system, SINJANI. Certain areas e.g. patient administration, pharmacy and others however, make use of electronic platforms in which individuated data is entered electronically into other specific provincial information systems. Various parallel information systems are also utilised in many areas of the public health sector such as research databases, however these are not linked to provincial platforms.

The Western Cape Department of Health (WCDOH) is currently building a comprehensive Health Information Exchange (HIE) in which all person-level hospital and clinic administrative

data, laboratory data, pharmacy data and data from disease information systems for HIV and TB are consolidated in a single environment, leveraging the existence of a unique patient identifier which is used as the folder number in all health facilities in the public sector. The WCDOH sought to further improve health surveillance and information availability on the clinical platform by digitising POCT results for entry into the HIE.

Point of care and laboratory testing

In recent times, the use of POCT has risen in healthcare as it improves access to healthcare and timely management of patients. The widespread use of GeneXpert technology for tuberculosis diagnosis and rapid testing for HIV diagnosis are well-known examples of POCT to expedite diagnosis and appropriate management, which, in turn, reduces spread of infection(2). At health facilities in the Cape Metro, numerous POC tests are conducted by various staff members such as doctors, nurses, nursing assistants, HIV counsellors and others. HIV POCT is primarily conducted by externally contracted HIV counsellors who are appointed by non-governmental organisations (NGO). Nurses and doctors conduct HIV tests in emergency settings e.g. during labour and when counsellors are unavailable e.g. after-hours. Results of such tests are hand-written in the patient records that remain in patient folders. Laboratory investigation specimens are collected by doctors, nurses and certain allied health professionals who place the relevant specimens and NHLS request form in designated NHLS collection points within the facility, for daily collection and delivery to specific laboratories within the Cape Metro. Laboratory test results can be accessed electronically at facilities for clinical assessment and decision-making.

The role of POCT within central laboratory services remains unclear. In the current model, where POCT is conducted by clinical staff, numerous concerns regarding quality assurance are raised. Studies have shown an increase in pre-analytical errors with POCT compared to central laboratory testing(1). Clinical staff may not have undergone the same rigorous training as laboratory staff with respect to POCT. Given these concerns, the presence of peripheral laboratories and laboratory staff within facilities may be the preferred model, particularly from a laboratory perspective. The feasibility and cost implications of this model have not been explored and may be challenging to implement in under resourced settings.

Pilot intervention to digitise POCT HIV results

The WCDOH sought to pilot an intervention to digitise POCT results through electronic capture of paper-based forms and integration within the HIE. Given the close link between laboratory tests and POCT, integration of POCT into the laboratory platform was considered advantageous.

Furthermore, the NHLS is equipped with an efficient transport service that has daily contact with all provincial health facilities where POCT is utilised. Integration of POCT results into an existing effective system was thus deemed more efficient and less onerous than developing a parallel system for POCT result digitisation. Furthermore, the intervention may also present a business incentive to NHLS, supported by WCDOH.

Although numerous POC tests are conducted in the public health sector, HIV testing is an example of a highly prevalent disease based solely on a POC rapid-testing algorithm, with only discordant findings resulting in a specimen sent to a laboratory. POC HIV results are entered manually into a facility register and aggregated data are submitted to the provincial information management team on a weekly or monthly basis. In order to test the feasibility of digitisation of POCT and integration within the health information, digitisation of HIV test results and integration into the HIE was piloted at a primary level community health centre in the Cape Metro.

Key stakeholders in the intervention pilot are listed below:

- WCDOH:
    - Managers at Health Programmes
    - Key role players in Strategy and Health Support including representatives from Knowledge Management and Health Impact Assessment
- NHLS:
    - Managers
    - Lab technologists and data clerks
- Facility level:
    - Facility managers
    - HIV Counsellors
    - Clinical staff

Several consultative meetings were held with key stakeholders to formulate the intervention. The intervention was developed so that the process had minimal interference with existing processes (Figure 1) and did not place additional administrative workload on facility staff. The standard HIV Consent and Testing (HCT) form (Appendix 1) used for all POC HIV testing which includes patient consent, POCT results and other clinical information relevant to HIV testing was utilised for the pilot intervention. Carbonated copies of these HIV testing forms, completed manually by HIV counsellors at the facility, were transported to a central location for data capturing and inclusion in the HIE from May 2017 until October 2018, as illustrated in Figure 2. Counsellors and nursing staff underwent a 3-hour training session on this revised data flow process.

Figure 1: Original Data Flow Pathway for HIV POCT

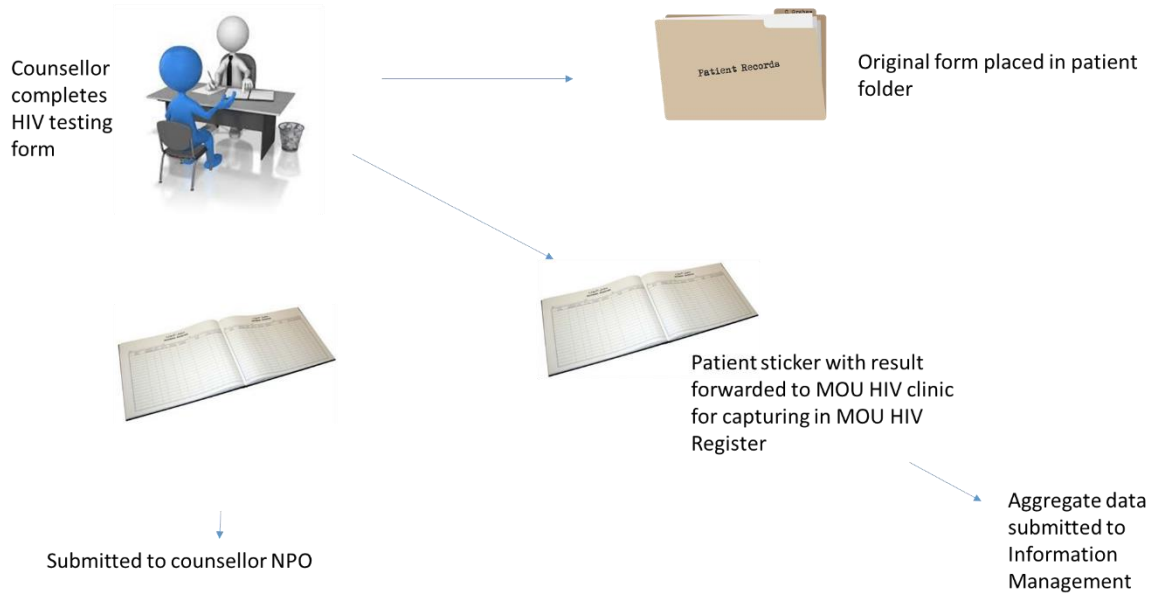
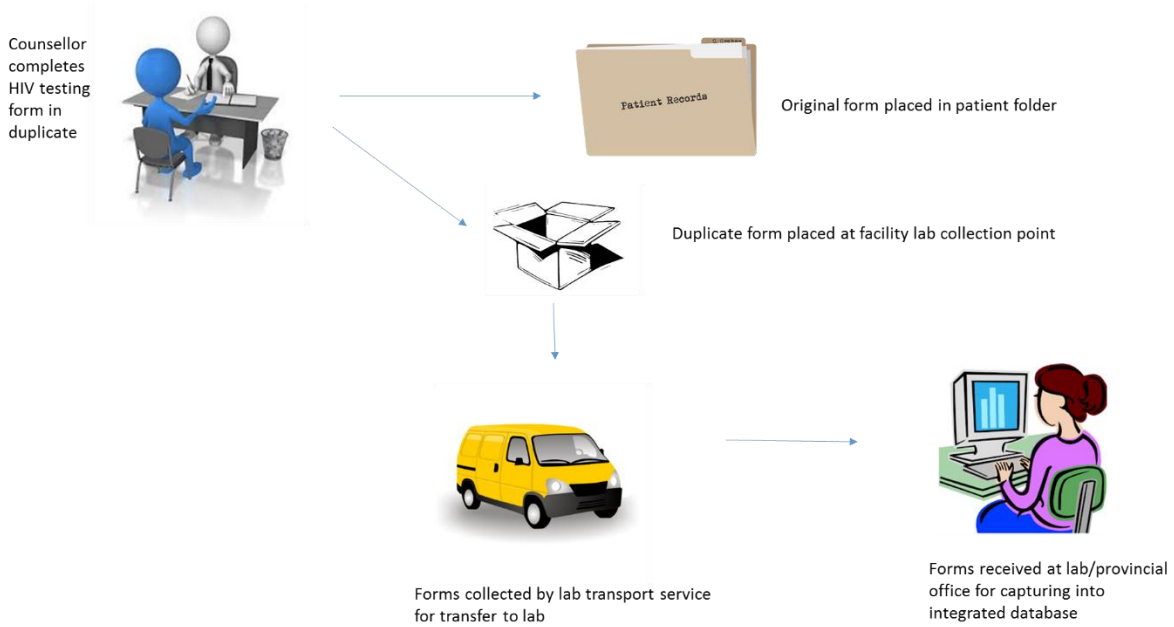


Figure 2: Revised data flow pathway (Intervention) for HIV POCT



While addressing the various concerns raised initially by NHLS, a parallel capture platform was setup at the WCDOH provincial office from November 2017 until April 2018. Forms were transported to the provincial office, independent to NHLS transport, for double capturing on the Provincial RedCap database by an independent, trained data capturer. Double capturing was employed to minimise capturing errors and hence improve data quality. Discrepancies in double

captured data were identified and corrected by the data capturer through validation with the carbonated form copy. Once validated, data was exported from the provincial database and integrated into the HIE. From January 2018, the NHLS commenced single capturing of HIV POCT results by data clerks employed by the NHLS. Captured data was checked by a supervisory laboratory technologist who authorised entry into the LIS, with a disclaimer indicating that the results were not verified by NHLS as the tests were conducted by facility staff. Test results were then made available for look-up by clinicians on the NHLS information platform, TrakCare Web Results Viewer, and integrated into the HIE for surveillance and clinical governance by the Provincial Department of Health.

Implementation Challenges

Stakeholder concerns

NHLS

Despite the perceived advantages of incorporating POCT within the NHLS platform, NHLS was reluctant to participate in the intervention for various reasons. A major concern, well documented in the literature, was the lack of quality assurance for POCT conducted by clinical staff who lacked laboratory training in quality control. Furthermore, the method of capturing results may not comply with the strict accreditation standards upheld by NHLS. Despite attempts to allay these concerns by ensuring that all POCT results would carry a clear disclaimer, NHLS was still hesitant. There was a sense that WCDOH was intruding into an area for which NHLS had more expertise and mechanisms to implement independently. This notion of professional exclusivity is well-described in literature as a health system-related barrier to adoption of POCT strategies(2). There were also concerns that the proposed intervention would increase NHLS workload for data clerks and technologists. Additionally, there was a sense that this increased workload would not be adequately compensated by WCDOH. Given this reluctance, WCDOH decided to implement the intervention using a parallel capturing system while continuing to engage with NHLS regarding feasible methods of collaboration. After several months of continued discussions at national and provincial level, NHLS agreed to participate in the pilot. Capturing processes were handed over to the NHLS at a high cost, comparable to costs of standard laboratory investigations.

Facility

Despite the drive and commitment to improve health information systems at a provincial and facility management level, a commonly held perception among staff at facility level is that improved data collection requires increased administrative workload for staff. Many staff members

felt that administrative requirements constantly change and add to their workload, preventing them from adequately engaging with their core duties of administering clinical care to patients. Benefits from improved data collection are rarely experienced by staff members and feedback is often not adequately provided or understood. Furthermore, the value of many interventions cannot be demonstrated until the process is adequately implemented over time. This results in poor motivation to successfully implement new interventions.

Although the initial WCDOH proposal was to introduce an intervention which facilitated digitisation of all POCT, this would require development of a new form containing all POCT results entered on standardised stationery. Such an intervention would increase workload for staff members without adding value to their immediate clinical duties. A key consideration during development of the intervention was that workload would not be increased through added administrative processes. The importance of consultation and consideration of frontline staff needs was recognised as imperative to successful implementation of the intervention. The proposed intervention was thus redesigned to include HIV POCT only, for which a standard pathway of data flow was in place (Figure 1).

Patient record data quality

During the initial provincial data capturing from carbonated form copies, form completion issues were identified such as poorly legible forms and incorrectly completed forms. Issues relating to legibility of carbonated forms and uniformity of carbonation in the form copies were identified and addressed with the printers. Although some fields in the form were not routinely filled by counsellors, entries pertaining to POCT were expected to be completed fully and emphasised during training. Only identifying data (hand-written or on patient labels stuck on the form) and fields relevant to POCT were captured. Data capturing was supervised by a project manager with a clinical background, who thus had a better contextual understanding of form completion in a clinical setting. Form issues that could not be resolved by the project manager, were discussed directly by the project manager with the HIV counsellors and facility management regularly.

Once capturing commenced via NHLS, resolution of form-specific issues were not addressed efficiently due to limited direct communication between NHLS and facility management and staff. Furthermore, poorly legible forms and incomplete forms were immediately rejected for capturing due to the strict accreditation criteria followed by NHLS.

Coincidentally, in January 2018, the pilot facility employed an additional NGO in order to increase HIV testing at the facility. There was an increased drive for opportunistic HIV screening in the facility and facility parking lot. The introduction of new, untrained counsellors with a high

counsellor turnover, resulted in more form-related issues and form rejections by NHLS. Furthermore, the increase in opportunistic testing, resulted in more patients without facility-generated patient stickers and unique patient folder numbers. Hand-written patient identifiers used for these patients were largely unacceptable to the NHLS. Forms without computer-generated patient labels frequently did not have a location code. Such forms were immediately rejected by NHLS as accreditation criteria require a location code for all specimens processed. Some patients were given computer-generated temporary numbers due to technical issues on the electronic administrative platform for facilities. These temporary numbers were also problematic for NHLS. Some counsellors erroneously used computer-generated patient labels from other sites that patients sometimes kept with the patient-held maternity case record. These labels contained location codes of facilities external to the pilot site and hence were also rejected by NHLS. During provincial capturing, however, all available identifiers including hand-written identifiers, temporary numbers and identifiers on labels from other facilities were captured as best as possible for potential linkage to the HIE.

As a response to these challenges, a direct communication chain between NHLS and the facility manager was instituted so that both parties could better understand and address form-related concerns and facility-related factors such as training of HIV counsellors, patient registration issues and others. Direct involvement of facility management would also increase accountability of individual counsellors who report to the facility manager. Despite these efforts, many issues remained unresolved.

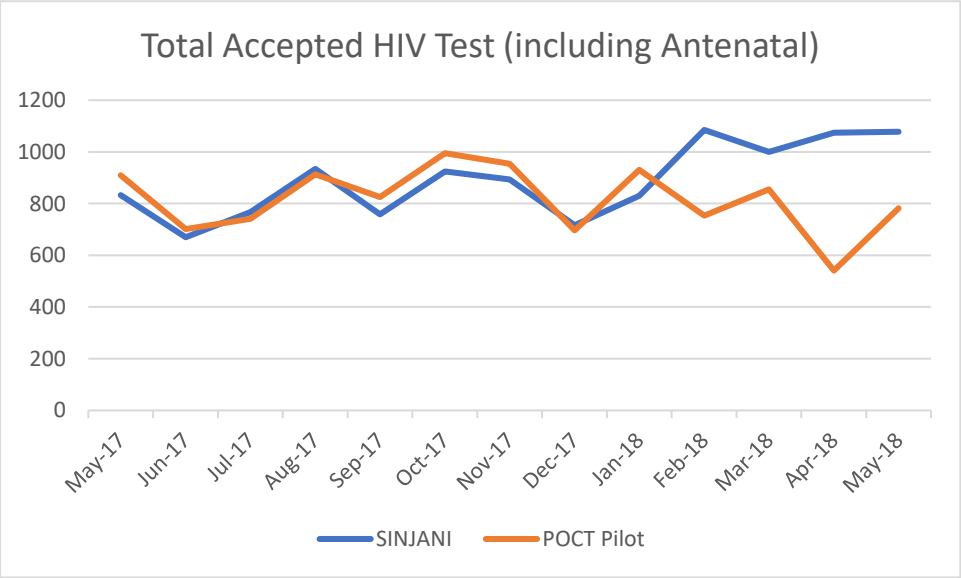
Logistical issues

Several logistical issues relating to routing and transport of the forms were identified and addressed on an ongoing basis. These issues included the unavailability of envelopes for form transport and poor labelling of envelopes. The issues were addressed by providing pre-labelled envelopes to the facility and regularly monitoring stock availability. The use of these envelopes for matters unrelated to the pilot was difficult to manage remotely. Although the NHLS requested that forms are sent to them daily, counsellors would often batch forms over several days for routing to NHLS as entry into the paper-based register was often delayed.

Results

From May 2017 to June 2018, 11 337 HIV counselling and testing forms were captured. Data was analysed in aggregate form and thereafter linked to the PMI for individual analyses. In total, 137 forms were excluded from aggregate analyses due to incorrectly entered dates of test. A comparison of aggregate data submitted to the provincial information system, SINJANI, independently of the pilot, and monthly data collected during the provincial phase of the pilot, showed a high correlation. (Figure 3)

Figure 3: Comparison of aggregate data from SINJANI and POCT Pilot



Divergence occurred from January 2018 onwards when the capturing platform transition occurred. Reporting elements from the routine HCT register extracted from SINJANI were further compared to pilot data over a 6-month period when provincial capturing was well established.

The captured forms were linked to the Patient Master Index of the Health Information Exchange using patient folder numbers. Where folder numbers were unavailable or illegible, linkage was attempted using combinations of other patient identifiers such as name, surname and date of birth. Overall, 97% linkage to PMI was achieved. Unlinked forms had limited identifiers or could not be definitively linked to a single patient with the available identifiers.

Of the 11 337 forms captured, 70% (7954) were captured on the provincial platform and 30% (3383) were captured on the NHLS platform. Linkage of forms to the PMI was 96% and 98% on the provincial and NHLS platforms respectively. Table 1 shows the completeness of variables captured from the forms.

Table 1: Completeness of variables captured

Variable	**% Completeness**
Date of test	99.6%
Reason for accessing service	73.9%
Sex	97.4%
Age	98.8%
Accept test	97%

Table 2 shows the key descriptive characteristics of patients tested during the pilot intervention.

Table 2: Descriptive characteristics

Variable	**Number (n=11337)**	**Median/Percentage**
Accepted test	10893	96%
Did not accept	108	
Accepted test, not known positive but not tested	163	
Age		28 years
Median age for females		27 years
Median age for males		31 years
Sex		
Female	8987	81.32%
Indeterminate/Unknown	23	0.2%

Male	2042	18.48%
Reason for accessing service		
ANC 1st test	2414	28.8%
20 wk rpt	637	7.6%
32 wk rpt	1465	25.1%
PICT other	2849	34%
Self-referred	597	7.12%
PMTCT/HIV exposed	340	4.1%
Perinatal (delivery)	1	0.01%
Baby other	2	0.02%
PICT TB	75	0.9%
Previous HIV result (self-reported)		
Self-reported positive	1492	13.2%
Self-reported negative	8325	73.6%
No entry	1500	13.3%

Of those who self-reported a positive HIV status, 88.2% were known to the HIE HIV Cascade as HIV positive and 7.7% only entered the HIV cascade after the HIV POCT encounter during the pilot intervention. Of those who self-reported positive, 24% re-tested for HIV during the POCT pilot intervention period. Most re-tests did not follow the HIV rapid testing algorithm as only 1 screening test was conducted if the patient self-reported positive HIV status. Overall, 84% of patients who self-reported HIV positive status were already on ART. However, 10.7% of those

who self-reported positive only started ART on same day as POCT, while 5.3% started ART a few days after POCT.

From the total sample, 77.2% of patient tested HIV negative and 8.8% tested positive as per HIV rapid testing algorithm. Linkage of newly diagnosed HIV positive patients to the HIV cascade showed that 34.8% of apparent newly diagnosed HIV positive patients were known to the cascade as HIV positive from previous evidences supporting an established diagnosis of HIV. These patients were therefore re-testing despite not self-reporting a positive HIV status. Of those patients who had previously tested positive, who re-tested, 49.4% self-reported known HIV positive status, while 50.6% did not report known HIV positive status. However, 46.7% of those who retested while not self-reporting HIV positive status, were already started on ART at some point before POCT. Of these patients, 9.5% were on ART previously, but not on ART within the last 3 months.

Figure 4 illustrates the impact on re-testing data when linking POCT data to the HIV cascade within the HIE. Figure 5 shows the difference in HIV testing data when reviewing the unlinked pilot findings in isolation compared to data linked to the HIV Cascade.

Figure 4: Comparison of POCT findings and HIV Cascade findings

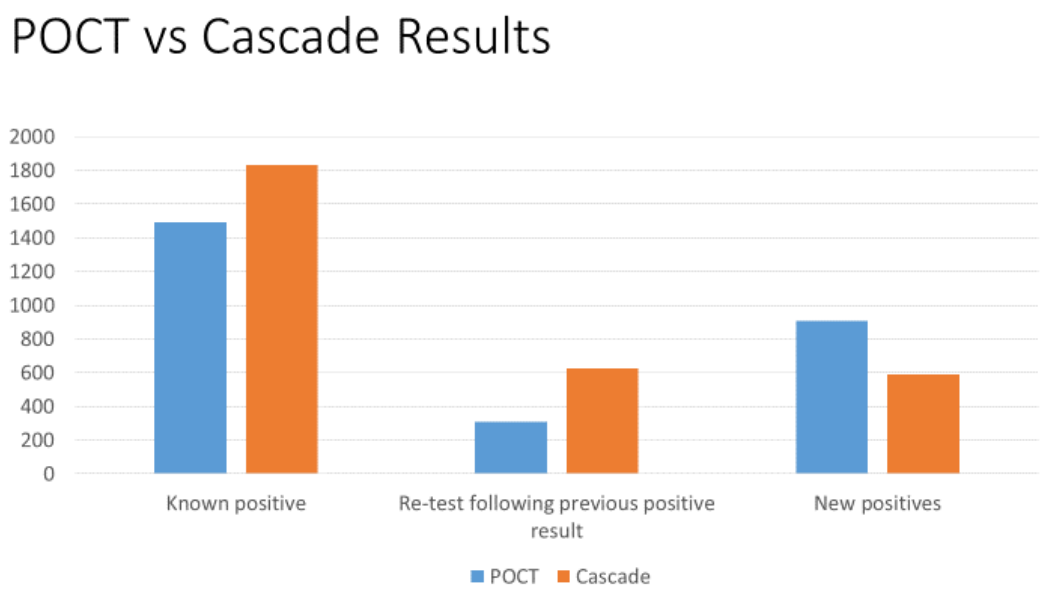
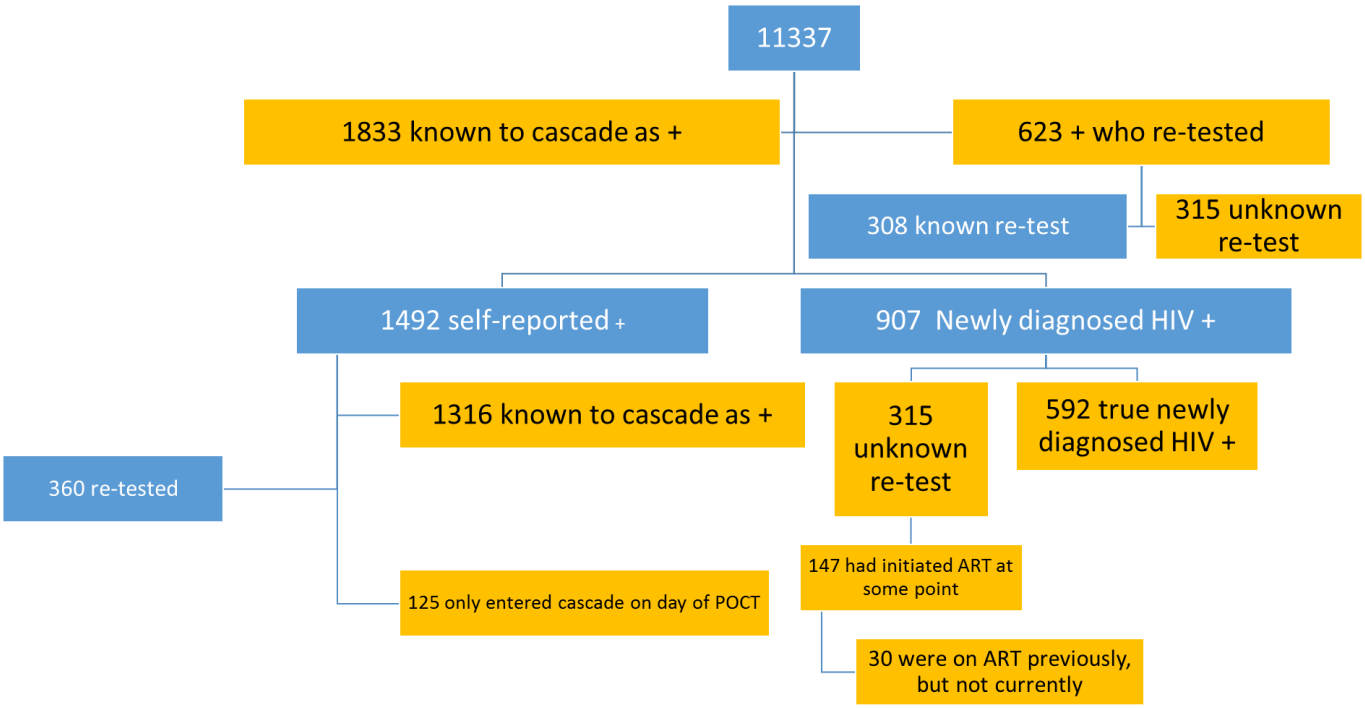


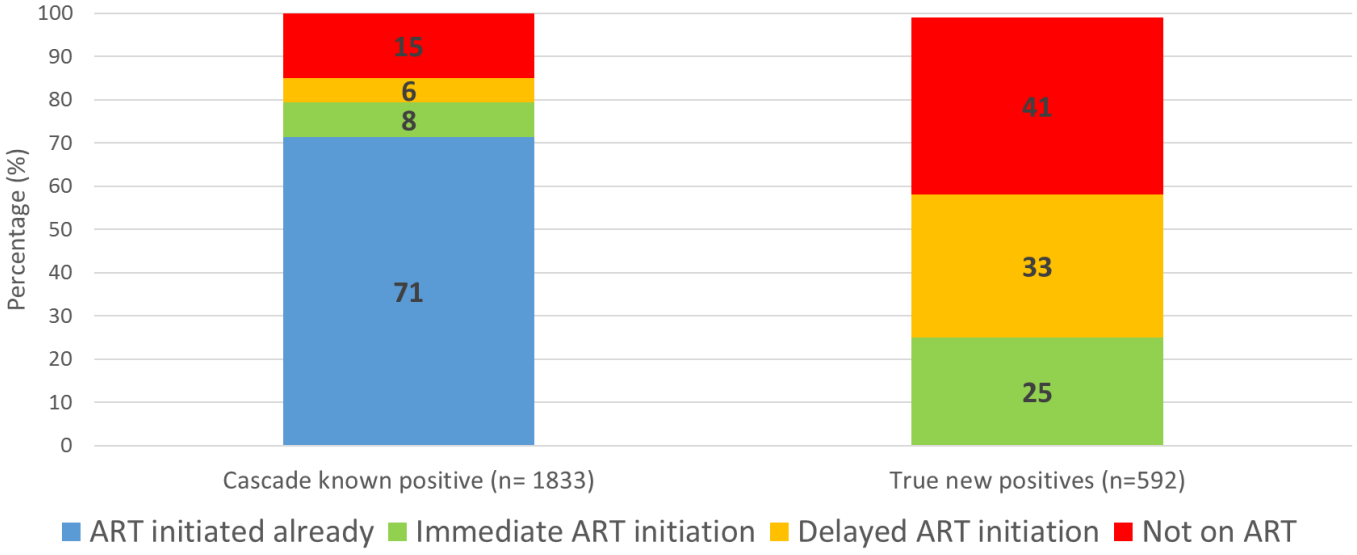
Figure 5: Flowchart of linked and unlinked HIV testing data



**Blue – unlinked data*
**Orange – linked data*

Of those patients newly diagnosed HIV positive as per linked HIV cascade data, 81.2% had evidence of linkage to further HIV care. Figure 6 illustrates the ART status of patients known to the cascade as HIV positive prior to the POCT pilot as well as the ART status of those newly diagnosed HIV positive. All patients attending for antenatal services were started on ART.

Figure 6: ART status



Discussion

The high correlation between aggregate data submitted to SINJANI and the POCT pilot data indicates that electronic registers from digitised data can successfully replace manual registers, significantly reducing the workload of clinical staff tasked with maintaining large paper-based registers while also providing timely individuated data for surveillance, clinical governance and facility management. However, once capturing was conducted by NHLS, the high number of form rejections rendered the data ineffective in generating electronic registers. Linkage to PMI was, however, higher when capturing occurred on the NHLS platform as forms without identifiers on patient labels were rejected.

Completeness and accuracy of routine data entry is imperative for a functional health information system. Although key variables achieved above 95% completeness, reason for accessing service was poorly captured. This variable was better captured in the antenatal services where reporting elements specific to this variable are required in the HTS register. The improvement of the accuracy of variables entered on the form requires on-going training, particularly for new counsellors. This is challenging due to limited resources and the high turnover of counsellors.

The individual analyses of data showed that the patients attending HTS during the POCT pilot were primarily women of a median age of 27 years. This is expected given that HTS in the pilot site is offered to all pregnant women attending the antenatal clinic. The reason for accessing services was frequently not completed on forms. Reasons related to antenatal services were better captured, most likely as there is a specific reporting element in the antenatal HIV register. The similarity between antenatal options for reason for accessing service may however cause confusion amongst those completing forms and result in incorrectly entered data on forms. For example, PMTCT/HIV exposed is intended as an indication for testing of infants, however may be misinterpreted as antenatal testing of women involved in PMTCT. Careful consideration of such fields on forms and ongoing training is needed to prevent inaccurate data entry and interpretation.

Only 13.2% of patients self-reported a previously positive HIV results. The majority of these patients were not tested, although 24% requested a re-test.

Further exploration is required to better understand reasons for re-testing among those who self-report a positive HIV status. The large majority of patients who self-reported as HIV positive were also know to the HIV cascade as positive on the basis of previous electronically captured evidence of HIV positive status. Those who self-reported HIV positive, but only entered the HIV cascade after the pilot intervention POCT may not have been linked to care after a previous POCT

diagnosis of HIV, hence no evidence of HIV positive status was available. Reassuringly, above 80% of those who self-reported HIV positive status were already on ART, while 10.7% only started ART after the pilot POCT. With test and treat guidelines not fully implemented in South Africa yet, many patients may not have met previous criteria for ART in the past and hence only recognised as requiring ART when re-tested. Digitisation of POCT can ensure that all diagnoses of HIV are available electronically, thus linkage to care can be evaluated and acted upon if necessary.

Overall, 8.8% of patients tested HIV positive as per the rapid HIV POCT algorithm of two positive HIV screening tests. However, more than a third of patients who tested positive and did not disclose a previous HIV status, were, in fact, known to the HIV cascade as HIV positive. Linkage of data to the HIV cascade thus reveals that the rate of re-testing is higher than anticipated. Only half of those who were known to be HIV positive in the HIV cascade, self-reported HIV positive status. However, 47% of these patients known to be HIV positive were on ART previously. Of those on ART, 9.5% were not on ART within the last 3 months. These patients may have had ART discontinued e.g. during a previous pregnancy when life-long ART was not instituted unless specific criteria were met. This discontinuation of ART may have led to perceptions that the patient was no longer HIV positive, hence prompting these patients to re-test. These potential reasons for re-testing require further exploration.

Of those newly diagnosed as HIV positive, 81.2% had evidence of linkage to HIV care. Of those already known to the cascade as HIV positive, 71% had already initiated ART. This is reassuring, however indicates the need to reach more HIV diagnosed individuals who are eligible to start ART according to current test and treat guidelines. Among those newly diagnosed with HIV, 25% initiated ART on the day of the pilot POCT diagnosis. All antenatal patients newly diagnosed as HIV positive were initiated on ART immediately, in keeping with option B+ guidelines, implemented prior to universal test and treat guidelines and thus well established in antenatal health facilities. Although immediate initiation of ART of HIV positive patients in non-antenatal settings is not widely practised in our setting, 41% of newly diagnosed HIV positive patients had not initiated ART following pilot POCT. Further investigation of clinical contra-indications for ART initiation and other reasons for non-initiation among these patients is required.

The pilot findings clearly demonstrate the added value of linkage of HIV POCT data to the HIV cascade. Re-testing rates, patient reporting of HIV status and linkage to care can be more accurately evaluated with these data, without adding to the administrative workload of clinical staff. This may

significantly contribute to more informed decision-making and resource allocation within HIV programmes.

Although it was difficult to demonstrate the value of the pilot during implementation, the intervention was acceptable and feasible to facility staff. Despite issues related to quality of POCT and quality of form completion, digitisation was still advantageous over existing processes. Furthermore, digitised data may provide better evidence for quality improvement. The utility of the intervention is similarly valued by WCDOH, although province-wide scale-up at the NHLS cost is unaffordable. Scale-up using a parallel data capturing system appears more feasible, but will still require significant resource investments for stationery, transport and capturing on a wider scale. From the central laboratory perspective, however, the intervention is onerous, poorly adherent to laboratory standards and of limited value. Higher level commitment and collaboration is required to streamline the intervention so that it is better supported within NHLS. The cost implications of digitisation through NHLS would also require careful consideration by WCDOH. The provincial capturing system was considerably more economically viable for the pilot intervention, however scale-up of the intervention may result in higher costs due to inefficiencies in maintaining a parallel provincial system. Further analysis of the exact costs involved in the NHLS digitisation process may be needed to finalise a more economically viable cost for potential scale up.

The implementation barriers encountered during this pilot intervention included technical and operational challenges, health system-related challenges and economic challenges. This pilot clearly illustrates the difficulties in balancing the needs and values of different stakeholders when developing and implementing an intervention. Many of the challenges experienced are reflective of health care challenges in LMIC where resources are limited and staff are overburdened, poorly supported and have limited understanding of systemic issues. Although the utility of digitising and integrating POCT data in the health information system can be demonstrated, the method of implementation requires considerable thought and planning. This pilot was designed with a strong health system focus, attempting to fully understand contextual factors in under resourced and highly pressured environments of health facilities. A highly consultative, bottom-up approach was used where the needs of frontline staff members were considered and incorporated in the development of the intervention. This consideration, however, conflicted with central laboratory implementation methods where a predominantly top-down approach is employed. This approach assumes a well-resourced environment where implementation is a straightforward technical process guided by strict criteria and standards. Although both approaches have their advantages and disadvantages, a fine balance is required for successful implementation and scale-up.

Additionally, this pilot shows that improved training, support and management of frontline healthcare staff, including externally contracted staff, is essential to ensure quality of patient care and data integrity. Improved feedback, communication and understanding between various components of the health system is imperative when instituting interventions within the health system.

In this setting, an alternative strategy to digitisation may be the complete replacement of paper-based systems with electronic systems and the exclusive use of digitised data for routine monitoring, clinical governance and personnel management. This would create more incentive to implement the intervention successfully and also address concerns of additional workload due to administrative interventions by reducing the heavy workload of maintaining paper-based systems. Such a strategy would allow greater freedom in the design of the intervention thus better incorporating needs of all stakeholders.

Conclusion

We demonstrate the important contribution of digitised PoCT data, within a robust HIE system, to better evaluate the HIV treatment cascade at both a population and an individual level. Improved estimation of the magnitude of retesting may have substantial implications for interventions to achieve 90-90-90 targets. The use of routine data for active surveillance and action is both efficient and cost-effective, an imperative in resource-constrained settings such as South Africa. In summary, the digitisation of PoCT can prompt earlier identification of patients lost to follow-up post an HIV positive test result, thereby triggering efforts to initiate appropriate care, and can improve our measurement of progress against the 90-90-90 targets.

References

1. Pai, N. P., Vadnais, C., Denkinger, C., Engel, N., & Pai, M. (2012). *Point-of-Care Testing for Infectious Diseases : Diversity , Complexity , and Barriers in Low- And Middle-Income Countries*. *9*(9). https://doi.org/10.1371/journal.pmed.1001306
2. Shaw, J. L. V. (2016). Practical challenges related to point of care testing. *Practical Laboratory Medicine*, *4*, 22–29. https://doi.org/10.1016/j.plabm.2015.12.002