A comprehensive review of the SLMTA literature part 2: Measuring success

Background: Since its introduction in 2009, the Strengthening Laboratory Management Toward Accreditation (SLMTA) programme has been implemented in 617 laboratories in 47 countries.

Objective: We completed a systematic review of the published literature on SLMTA. The review consists of two companion papers; this article examines quantitative evidence presented in the publications along with a meta-analysis of selected results.

Methods: We identified 28 published articles with data from SLMTA implementation. The SLMTA programme was evaluated through audits based on a standard checklist, which is divided into 12 sections corresponding to the 12 Quality System Essentials (QSEs). Several basic service delivery indicators reported by programmes were also examined. Results for various components of the programme were reviewed and summarised; a meta-analysis of QSE results grouped by the three stages of the quality cycle was conducted for 126 laboratories in 12 countries.

Results: Global programme data show improved quality in SLMTA laboratories in every country, with average improvements on audit scores of 25 percentage points. Meta-analysis identified Improvement Management as the weakest stage, with internal audit (8%) and occurrence management (16%) showing the lowest scores. Studies documented 19% – 95% reductions in turn-around times, 69% – 93% reductions in specimen rejection rates, 76% – 81% increases in clinician satisfaction rates, 67% – 85% improvements in external quality assessment results, 50% – 66% decreases in nonconformities and 67% increases in staff punctuality.

Conclusions: The wide array of results reported provides a comprehensive picture of the SLMTA programme overall, suggesting a substantive impact on provision of quality laboratory services and patient care. These comprehensive results establish a solid data-driven foundation for program improvement and further expansion.

Introduction

Quality laboratory services are critical for ensuring optimal patient care and comprehensive public health response; however, laboratories in resource-poor countries have been one of the most neglected components of health systems. The Strengthening Laboratory Management Toward Accreditation (SLMTA) programme was developed in an effort to improve the quality of laboratories throughout the developing world. It is a competency-based training programme designed to enable laboratories to implement practical quality management systems (QMS) and encourage continuous quality improvement.

Since its introduction in 2009, the SLMTA programme has been implemented widely throughout Africa, as well as in the Caribbean, Central and South America, and Southeast Asia. The primary focus of the programme thus far has been implementation and expansion; until recently, little attention has been paid to the systematic examination of programme results in order to guide programme improvement and decision making.

This systematic literature review aims to compile existing results from evaluations of the SLMTA programme into a comprehensive report, in order to provide a broad view of the programme and to identify directions for the future. Because of the large volume of information collected, the review has been published in two parts. In Part 1, published separately, we present content analysis of qualitative findings and identified strategic directions for future priorities. In this companion paper, we compile the quantitative data presented in the publications, examine scores and indicators, and conduct a meta-analysis of selected results in order to establish a solid, data-driven foundation for programme improvement and to help guide future implementation.
Research methods and design

A comprehensive search of electronic bibliographic databases was performed, as described in Part 1. We included all published and in-press studies that discussed the SLMTA programme.

The standard SLMTA implementation model includes three workshops, each of which is followed by a period of several months for laboratories to implement improvement projects, usually with onsite support and mentorship. Laboratories implementing the SLMTA programme are evaluated through audits based on the Stepwise Laboratory Quality Improvement Process Towards Accreditation (SLIPTA) checklist. Audit scores are categorized into star ratings, with zero stars corresponding to a score of 0%–54%, one star 55%–64%, two stars 65%–74%, three stars 75%–84%, four stars 85%–94%, and five stars 95%–100%. The checklist items are divided into 12 sections that represent the 12 Quality System Essentials (QSEs) as defined by the Clinical and Laboratory Standards Institute (CLSI). These QSEs can be grouped by stages of the quality cycle: Resource Management (equipment; facilities and safety; organization and personnel; purchasing and inventory), Process Management (client management; documents and records; information management; process control and internal/external quality assessment) and Improvement Management (corrective action; internal audit; management reviews; occurrence management). To assess progress, baseline and exit audits are conducted before and after SLMTA implementation, respectively, using the SLIPTA checklist. ‘Surveillance’ audits are also often conducted after the exit audit in order to monitor continued improvement and assess sustainability.

Several studies provided scores by individual QSEs. We combined these data and conducted a meta-analysis in Microsoft Excel 2013 so as to determine common areas of strength, weakness and improvement. For studies reporting only median or mean QSE data for multiple laboratories, laboratory-level data were solicited from authors to further enhance the analysis. All cost estimates reported in local currency in published articles were converted into US dollars, based on the official exchange rate as of August 1, 2014. Percent changes in indicator results were calculated from published results if not reported directly in the papers.

Results and discussion

Literature search results

We identified 28 published articles on the SLMTA programme (Table 1). In total, these studies included detailed information on SLMTA implementation in 211 laboratories in 18 countries, as well as global summary data from all 617 laboratories in the 47 countries that have implemented SLMTA as of the end of 2013.

| Study          | Country/Countries | Level of study | Number of laboratories | Years of study |
|---------------|-------------------|----------------|------------------------|----------------|
| Amedick et al. | Tanzania          | Select laboratory | 1                     | 2010–2011      |
| Audu et al.    | Nigeria           | Select laboratories | 2                     | 2010–2013      |
| Ena et al.     | Cameroon          | Select hospital  | 1                     | 2011–2012      |
| Gachuki et al. | Kenya             | Select laboratory | 1                     | 2010–2013      |
| Guevara et al. | Bahamas, Jamaica, Barbados, Trinidad and Tobago | One cohort | 5                     | 2011–2013      |
| Hiwot et al.   | Ethiopia          | Two cohorts     | 45                    | 2010–2012      |
| Lulie et al.   | Ethiopia          | Select laboratories | 17                    | 2013           |
| Maina et al.   | Kenya             | Select laboratories | 5                     | 2011–2012      |
| Malukika et al.| Kenya             | Select laboratory | 8                     | 2010–2011      |
| Maruta et al.  | NA                | Global          | NA                     | 2009–2013      |
| Marutu et al.  | Kenya             | Select laboratory | 1                     | 2011–2013      |
| Masamba et al. | Mozambique        | One cohort      | 8                     | 2010–2012      |
| Mataranika et al.| Namibia          | One cohort      | 6                     | 2012–2013      |
| Mokaloba et al.| Bostwana          | One cohort      | 7                     | 2010–2011      |
| Mothabeng et al.| Lesotho           | Two cohorts     | 18                    | 2010–2011      |
| Ndasi et al.   | Cameroon          | One cohort      | 5                     | 2009–2012      |
| Nguyen et al.  | Vietnam and Cambodia | General     | NA                     | 2012–2013      |
| Nkengasong et al.| NA                | General        | NA                     | NA             |
| Nkrumah et al. | Ghana             | Three cohorts   | 15                    | 2011–2013      |
| Nkwawir et al. | Cameroon          | Select laboratory | 1                     | 2009–2013      |
| Noble et al.   | NA                | General         | NA                     | NA             |
| Ntsaahbwa et al.| Bostwana          | Select laboratory | 1                     | 2010–2013      |
| Nazahakasana et al.| Rwanda         | Three cohorts   | 15                    | 2010–2013      |
| Ntwomebe et al.| Zimbabwe          | One cohort      | 19                    | 2010–2012      |
| Shumba et al.  | Zimbabwe          | Two cohorts     | 30                    | 2010–2012      |
| Yao et al.     | NA                | General         | NA                     | NA             |
| Yao et al.     | NA                | General         | NA                     | 2009–2013      |
| Yao et al.     | 47 countries*     | Global          | 617                   | 2010–2013      |

Source: Luman, Yao and Nkengasong®

SLMTA, Strengthening Laboratory Management Toward Accreditation; NA, not applicable.

*Angola, Antigua, Bahamas, Barbados, Belize, Botswana, Burundi,Cambodia, Cameroon, Columbia, Costa Rica, Cote d’Ivoire, Democratic Republic of the Congo, Dominica, Dominican Republic, El Salvador, Ethiopia, Ghana, Grenada, Guatemala, Haiti, Honduras, Jamaica, Kenya, Lesotho, Malawi, Mozambique, Namibia, Nicaragua, Nigeria, Panama, Peru, Rwanda, Sierra Leone, South Africa, South Sudan, St Kitts, Saint Lucia, Saint Vincent, Suriname, Swaziland, Tanzania, Trinidad and Tobago, Uganda, Vietnam, Zambia, Zimbabwe.

http://www.ajlmonline.org doi:10.4102/ajlm.v3i2.276
Global programme results

Data from all laboratories implementing the SLMTA programme were collated and summarised in a single paper describing the global results of the programme to date. In total, 617 laboratories in 47 countries on four continents have implemented SLMTA in 65 training cohorts, with nearly 2000 laboratory staff trained in the programme. Most of the laboratories were at the district (38%), regional (27%) or national (18%) levels. The authors report that the starting level of laboratory quality in developing countries was very low, with 84% of SLMTA laboratories scoring below the one-star level at baseline. The 302 laboratories that had completed the programme had an average improvement of 25 percentage points; 70% achieved at least one star at exit audit and 22% of laboratories increased three or more star levels.

Estimates of the number of laboratory tests conducted by SLMTA laboratories suggested that the 617 laboratories enrolled in SLMTA conduct more than 100 million tests annually and that whilst only 16% of these tests were conducted by laboratories with at least one quality star before SLMTA, 68% were done by laboratories with at least one star after SLMTA implementation. That translates to approximately 58 million tests conducted by laboratories with little to no QMS prior to SLMTA which now have at least a basic quality system in place.

Quality System Essentials meta-analysis

Examining individual SLIPTA checklist scores for each of the 12 QSEs enables laboratories to pinpoint strengths, weaknesses and areas of improvement. QSE data have not been compiled systematically on a global scale. From the published papers, QSE data were presented for 126 laboratories in 12 countries. Individual studies reported substantial variability in high- and low-scoring QSEs. For example, some laboratories scored 0% for five of the 12 QSEs at exit audit, whereas others scored 100% for the same five QSEs.

At baseline, the weakest areas overall were in the Improvement Management stage of the quality cycle, including internal audit (5%), occurrence management (16%), corrective action (29%) and management reviews (29%) (Figure 1). At an average of 20%, this stage scored less than half of the other two stages, namely, Resource Management (42%) and Process Management (40%). None of the 12 QSEs had mean baseline scores above 55%; the highest scores were in information management (51%), facilities and safety (47%), purchasing and inventory (42%) and process control and internal/external quality assessment (41%).

At the exit audit, the four Improvement Management QSEs still showed the lowest scores, ranging from 32% – 50% (average 42%) (Figure 1). The Resource Management and Process Management stages had higher scores ranging from 58% – 74% (average 65% for Resource Management and 63% for Process Management). The greatest improvements were in documents and records (34 percentage points), client management (29 percentage points), and facilities and safety (27 percentage points). Each of the three stages had the same average improvement of 23 percentage points.

Based on results from five laboratories, Maina et al. found that the laboratories with the greatest overall score increases had focused on internal audit and corrective action; they then hypothesised that an improvement in these areas may be a catalyst for overall improvement in other areas. Meta-analysis results suggest that the corrective action QSE may...
be the most predictive of overall improvement; laboratories in the top quartile of overall improvement outperformed those in the bottom quartile by 62 percentage points for the corrective action QSE, compared to a median of 40 percentage points for the other QSEs. CLSI defines corrective action as an ‘action to eliminate the (root) cause of a detected nonconformity or other undesirable situation’. In the SLIPTA checklist, corrective action is assessed through four questions about how the laboratory deals with occurrence reports, nonconformities and discordant results. The International Organization for Standardization (ISO) confirms the importance of corrective action, saying that ‘the corrective and preventive actions system is the most critical element for an efficient quality system’. Additional work is needed to verify priority areas of improvement, as well as to delineate the set of essential improvement projects that will result in meaningful laboratory quality improvement.

**Official WHO AFRO SLIPTA audits and accreditation**

A July 2009 survey of accrediting body registers identified 340 accredited laboratories in sub-Saharan Africa; only 28 (8%) of these laboratories were located outside of South Africa and nearly all were private, parastatal or donor-supported research facilities. By early 2013, little progress had been made, with 380 laboratories accredited in the region; only 35 (9%) laboratories outside of South Africa were accredited and three quarters of the 49 countries in the region had no accredited laboratories. However, the impact of SLMTA is beginning to show; as of September 2014, six laboratories enrolled in SLMTA in Kenya, the Bahamas, Vietnam and Zimbabwe have been accredited, at a median of 31.5 months after starting the SLMTA programme. Several laboratories have been recommended for accreditation or are in the process of application. Ninety-seven SLMTA laboratories have received official WHO AFRO SLIPTA audits conducted by representatives from the African Society for Laboratory Medicine, including 11 laboratories in published reports included in this review.

**Service delivery indicators**

In addition to audit scores, many of the studies reported improvements for indicators reflecting testing and customer and clinician satisfaction (Table 2). Three studies reported reductions in turnaround time for testing, with times decreasing by 19%–95%. Patient and clinician satisfaction were commonly measured using surveys. Four studies showed relative improvements in patient satisfaction ranging from 30% to >100%, although in one laboratory complaints from patients increased, possibly as a result of staff attrition. Two studies reporting on clinician satisfaction found improvements of approximately 80%. Indicators for laboratory management and overall functioning also showed improvements (Table 2). One laboratory reported a 65% decrease in corrective actions, five laboratories in the Caribbean Region reported decreases in nonconformities of 50%–66% and two laboratories showed improvements in external quality assessment results of 67%–85%. In a Kenyan laboratory, staff punctuality increased 67% and the need for equipment repairs decreased 63%. A Botswana laboratory successfully reduced losses resulting from expired reagents from $18 000 in 2010 to $40 in 2013 and three studies showed reductions in specimen rejection rates of 69%–93%. When SLMTA was adapted and implemented at a hospital in Cameroon, patient wait times decreased 67%–83%, infection rates and stillborn rates decreased (83% and 80%, respectively) and the number of patients and hospital revenue increased.

**Cost**

The reported costs per laboratory of implementing various components of SLMTA have varied widely (Table 3). Much of this variability is because of differences in what was included in the cost estimates, as well as location-specific factors, such as the price of fuel, salary levels and distances to participating laboratories. The estimated cost of conducting the three-workshop SLMTA series has ranged from $1482 per laboratory in Zimbabwe using local facilitators in a central location to $21 480 in Cameroon using decentralised training. Mentorship cost per laboratory has ranged from $5689 in Zimbabwe to $24 000 in Ghana. The cost of implementing improvement projects has ranged from $10 000 in Ghana to $36 500 in a Kenyan laboratory seeking accreditation.

Three studies have compared the cost of various SLMTA implementation models. One study of 19 laboratories in Zimbabwe found that mentorship and supervision costs for four different models were similar ($5689–$9601 per laboratory), recommending that ‘countries should carefully consider which mentorship model or models would be best suited to their individual situation’. Another study in Zimbabwe found that implementing SLMTA using local (in-country) facilitators is more expensive than external facilitators for the first SLMTA cohort because of the costs associated with conducting an in-country training-of-trainers; however, over the course of national scale-up in 120 laboratories, use of local facilitators would save the country nearly 50% ($580 000 vs. $322 000). A Cameroonian study found that the cost per laboratory of centralised training was approximately the same as decentralised training ($21 122 vs. $21 480, respectively); centralised training required less trainer time, whilst decentralised training allowed more staff to participate.

No published studies to date have reported a thorough examination of the cost of implementing the entire SLMTA programme, including each of the major components (training of mentors, trainers and auditors; conducting SLMTA workshops; mentorship, supervisory visits and implementation of improvement projects; and conducting audits). In addition, a more extensive cost-benefit analysis taking into consideration the value of laboratories’ time (i.e., opportunity cost) to participate in the programme and
| Study | Indicator | Method of measurement | Comparison periods | Result reported | Percent improvement (calculated) |
|-------|-----------|-----------------------|-------------------|----------------|----------------------------------|
| Eno et al.8 | Patient wait time in the emergency ward | Maximum patient wait times from arrival to departure from emergency room, estimated by scanning log books | Not specified (before and after SLMTA implementation) | Decreased from > 3 hours to < 30 min | 83% |
| | Maximum overall patient wait time | Maximum patient wait times from arrival to laboratory results, estimated by scanning log books | Not specified (before and after SLMTA implementation) | Decreased from 3 days to < 1 day | 67% |
| | Patient satisfaction | Proportion of patient suggestion box forms submitted with positive comments | Not specified (before and after SLMTA implementation) | Increased from 15% to 60% | 400% |
| | Staff awareness of quality improvement programmes | Estimated by hospital director after inquiries | Not specified (before and after SLMTA implementation) | Increased from 10% to 75% | 750% |
| | Hospital hygiene | Proportion of toilets that were functional in the facility | Not specified (before and after SLMTA implementation) | Decreased from 7% to 3% | 85% |
| | Infection rate | Estimated by the theatre nurse | Not specified (before and after SLMTA implementation) | Decreased from 3% to 0.5% | 83% |
| | Stillborn rate | Estimated by the midwife of the maternity ward using birth records | Not specified (before and after SLMTA implementation) | Decreased from 5% to < 1% | 80% |
| | Number of patients | Estimated by hospital director | Not specified (before and after SLMTA implementation) | Increased (amount not specified) | Unknown |
| | Hospital revenue | Provided by hospital director | Not specified (before and after SLMTA implementation) | Increased from $1638 to $2047 | 25% |
| Gachuki et al.10 | Turnaround time for viral load testing | Review of data in the laboratory information management system | 2010 versus 2013 | Decreased from 20 days to 6 days | 70% |
| | Turnaround time for ELISA testing | Review of data in the laboratory information management system | 2010 versus 2013 | Decreased from 191 days to 10 days | 95% |
| | Turn-around time for CD4 testing | Review of data in the laboratory information management system | 2010 versus 2013 | Decreased from 24 hours to 12 hours | 50% |
| | Service interruption days per month due to equipment downtime and stock outs | Review of data in the laboratory information management system | 2010 versus 2013 | Decreased from 15 days to 0 days | 100% |
| | Patient satisfaction | Patient complaints summarised from patient feedback forms | 2010 versus 2013 | Decreased complaints from 12 to 5 | 58% |
| | Specimen rejections | Review of data in the laboratory information system | 2010 versus 2013 | Decreased from 133 to 9 | 93% |
| | Corrective actions and occurrence management | Analysis of corrective action forms and quarterly reports | 2010 versus 2013 | Decreased from 74 to 26 | 65% |
| | External Quality Assessment results | Average correct responses on External Quality Assessment panel tests | 2010 versus 2013 | Increased from 60% to 100% | 67% |
| Guevara et al.11 | Number of nonconformities | Count of nonconformities in five laboratories | At baseline and surveillance audits to 2013 | Decreased from 100 to 56; 77 to 32; 93 to 32; 61 to 24; and 58 to 32 | 50%, 58%, 66%, 61%, 60% |
| | Number of standard operating procedures completed | Count of procedures completed in five laboratories | NA | Decreased from 205, 456, 292, 735, and 141 standard operating procedures | NA |
| Lulie et al.14 | Stock outs | Anecdotal report from laboratory managers | Not specified (before and after SLMTA implementation) | Decreased (amount not specified) | Unknown |
| | Interruption of service resulting from equipment problems | Anecdotal report from laboratories | Not specified (before and after SLMTA implementation) | Minimised (amount not specified) | Unknown |
| Maruta et al.16 | Utilisation rate among graduates from the training-of-trainers programme | Survey of 195 participants asking whether they had delivered at least one SLMTA training or were still involved in SLMTA programme activities | NA | 92% | NA |
| | Effectiveness of training-of-trainers programme | Survey of 195 participants asking whether the training was effective in preparing them to implement programme | NA | 97% | NA |
| Maruti et al.17 | External Quality Assessment results | Average correct responses on External Quality Assessment panel tests for 33 analytes, 3 times per year | 2010 versus 2013 | Increased from 47% to 87% | 85% |
| | Staff punctuality | Average overall percent of person-days that staff arrived on time for their shift, based on employee time clock data | 2011 versus 2013 | Increased from 49% to 82% | 67% |
| | Clinician satisfaction | Proportion of forms submitted with complaints | 2011 versus 2013 | Complaints decreased from 83% to 16% | 81% |
| | Patient satisfaction | Proportion of forms submitted with complaints | 2012 versus 2013 | Complaints increased from 3% to 22% | -700% |
| | Sample rejection rate | Average rejection rate | 2011 versus 2013 | Decreased from 12% to 3% | 75% |
| | Equipment repairs needed | Number of equipment repairs in the laboratory | 2011 versus 2013 | Decreased from 40 to 15 | 63% |
| | Ability to repair equipment internally | Proportion of equipment repairs carried out by internal engineers versus external | 2011 versus 2013 | Increased from 20% to 80% | 400% |

SLMTA, Strengthening Laboratory Management Toward Accreditation; ELISA, enzyme-linked immunosorbent assay; NA, not applicable; CSF, cerebrospinal fluid.

Table 2 continues on the next page ➔
implement changes in the laboratory along with tangible and intangible benefits of the programme is needed.21

Limitations to the study
This review is subject to several limitations. Firstly, whilst 28 studies on SLMTA were identified and summarised, these reflect only 18 (38%) of the 47 countries and 211 (34%) of the 617 laboratories that have implemented the programme. Their results may not be representative of the programme as a whole, or a comprehensive account of all laboratories’ experiences. Secondly, whilst audit results were available for all laboratories because of the use of the SLIPTA checklist, the other indicators presented here were available in few of the published studies; in addition, methodologies varied between the studies, limiting the ability to combine and compare results directly. Authors of the studies published thus far also point out several limitations. Firstly, the SLMTA programme as a whole is too young to allow an assessment of the long-term sustainability of results;14,23 Secondly, all of the published studies were observational; several studies examining the effect of mentorship or training methodologies note that laboratories were not assigned randomly, but were rather selected purposively based on convenience or other programmatic considerations. Thus there may have been other factors that could account for some of the differences.8,15,20,30 Similarly, none of the studies included control laboratories upon which to base a comparison.22 Thirdly, there is a lack of consistency in the qualifications of auditors; whilst the SLIPTA checklist is designed to help standardise the audit process, some variability between auditors may remain.8,29 Finally, several authors noted that their published studies are based on a small number of laboratories14,15,20,30 and some indicators were either not measured systematically14 or not measured at baseline.8,28

Conclusion
In their summary of global-level findings, Yao et al. point out that ‘few [other] management and leadership development programmes have been implemented on a such a large scale with results-oriented outcome measures’.20 The wide array of results reported provides a comprehensive picture of the SLMTA programme overall, suggesting a substantive impact on provision of quality laboratory services and patient care. The full potential of the programme can be realised only if the lessons learned lead to informed action among laboratory workers, healthcare providers and policy makers toward the ultimate goal of providing quality patient care.

Acknowledgements
We would like to thank the lead authors of the in-press papers for allowing us to examine their results prior to publication, making it possible to publish this review simultaneously with their work: Linda Andiric, Rosemary Audu, Laura Eno, Thomas Gachuki, Giselle Guevara, Tilahun Hiwotu, Adino Lulie, Robert Maina, Ernest Makokha, Talkmore Maruta, Phidelis Maruti, Jessina Masamha, Mary Mataramyika, Kelebeletse Mokobela, Juliana Ndasi, Thuong Nguyen, Bernard Nkrumah, Siyem

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TABLE 2 (Continues...): Health service indicators associated with SLMTA implementation as reported in published studies.

| Study                                      | Indicator                                      | Method of measurement                                      | Comparison periods                          | Result reported                     | Percent improvement (calculated) |
|--------------------------------------------|------------------------------------------------|------------------------------------------------------------|---------------------------------------------|-------------------------------------|----------------------------------|
| Mokobela et al.25                           | Turnaround time for laboratory testing         | Anecdotal report from laboratories                        | Not specified (before and after SLMTA implementation) | Decreased (amount not given)        | Unknown                         |
| Nkrumah et al.25                            | Specimen rejection rates                       | Percentage of total number of samples rejected, averaged over four laboratories | 2011–2013                                    | Decreased from 32% to 10%          | 69%                             |
|                                            | Patient satisfaction                            | Proportion of patient suggestion box forms submitted with positive comments, averaged over four laboratories | 2011–2013                                    | Increased from 25% to 70%          | 300%                            |
| Ntshambiwa et al.20                         | Turnaround time for haematology                | Analysis of results from the Integrated Patient Management System | April – September 2011 versus October 2011 – March 2012 | Decreased from 72 minutes to 58 minutes | 19%                             |
|                                            | Turnaround time for chemistry                   | Analysis of results from the Integrated Patient Management System | April – September 2011 versus October 2011 – March 2012 | Decreased from 154 minutes to 86 minutes | 44%                             |
|                                            | Turnaround time for CSF                         | Analysis of results from the Integrated Patient Management System | April – September 2011 versus October 2011 – March 2012 | Decreased from 152 minutes to 106 minutes | 30%                             |
|                                            | Turnaround time for pregnancy tests            | Analysis of results from the Integrated Patient Management System | April – September 2011 versus October 2011 – March 2012 | Decreased from 97 minutes to 46 minutes | 52%                             |
|                                            | Patient satisfaction                             | Proportion of patients indicating ‘good’ or ‘very good’ on survey forms | 2011 versus 2013                             | Increased from 56% to 73%           | 30%                             |
|                                            | Clinician satisfaction                          | Proportion of clinicians indicating ‘good’ or ‘very good’ on survey forms | 2011 versus 2013                             | Increased from 41% to 72%           | 76%                             |
|                                            | Reagent wastage                                 | Calculated laboratory losses resulting from expired reagents | Fiscal year 2011 versus 2013                 | Decreased from $18 000 to $40       | > 99%                            |
|                                            | Number of standard operating procedures completed | Count of procedures completed                             | NA                                          | 154 standard operating procedures | NA                              |

SLMTA, Strengthening Laboratory Management Toward Accreditation; ELISA, enzyme-linked immunosorbent assay; NA, not applicable; CSF, cerebrospinal fluid.
Nkwawir, Michael Noble, Keoratile Ntshambiwa, Innocent Nzabahimana, Phoebe Nzombe and Edwin Shumba. Special thanks go to Philip Rotz, Lee Schroeder, Bethanie Rammer and Penny Smorenburg for their valuable feedback in manuscript revision.

This research has been supported by the President’s Emergency Plan for AIDS Relief (PEPFAR) through the CDC.

Competing interests
The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors’ contributions
E.T.L (CDC, Atlanta) analysed the data and wrote the manuscript. K.Y. (CDC, Atlanta) and J.N.N (CDC, Atlanta) provided substantial input to the revision of the manuscript.

CDC disclaimer
The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the CDC.

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