Enhancing cervical cancer screening coverage in selected primary healthcare sites using Lean thinking: The CerviScreen programme

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Background. Cervical cancer is the most common malignancy among South African (SA) women of reproductive age, with women living with HIV (WLWH) facing a six-fold higher susceptibility. The National Department of Health recommends baseline cervical cancer screening (CCS) for WLWH upon HIV diagnosis. SA's reported CCS rate is 19.3%, despite the World Health Organization (WHO)'s recommended 2030 target of 70%. AIDS Healthcare Foundation initiated the CerviScreen programme to improve CCS rates using Lean thinking.
Objectives. To evaluate the effect of the programme on CCS coverage over a 7-month period at selected sites in the Eastern Cape and KwaZulu-Natal provinces of SA.
Methods. This quantitative, controlled before-and-after study retrospectively evaluated changes in CCS coverage at purposively selected quality improvement programme (QIP) sites, compared with matched control sites. Key CCS indicator data from Lean A3 tools were analysed. Repeated analysis of variance measures tested changes in CCS proportions over time, at a $p<0.05$ significance level.
Results. Nine CerviScreen and nine control sites per province were assessed. Significant increases in CCS mean proportions were observed at QIP sites in KwaZulu-Natal (5% - 62.9%; F=8.336, $p<0.001$) and Eastern Cape (21.2% - 82.4%; F=15.525, $p<0.001$) provinces. Differences in the change of mean proportions between CerviScreen and control sites were not statistically significant in KwaZulu-Natal (F=0.022, $p=0.884$) and Eastern Cape (F=0.882, $p=0.362$). Clinically significant improvements were observed, with the estimated marginal mean at KwaZulu-Natal QIP sites consistently surpassing control sites from month 3 onwards. Eastern Cape sites maintained over 80% coverage from month 4. Screening coverage trends differed significantly between provinces (F=11.12, $p=0.004$).
Conclusion. Lean thinking, through the CerviScreen programme, has potential to enhance and accelerate CCS among SA WLWH toward attaining the WHO target. The findings underscore the importance of adopting systematic quality improvement approaches, highlighting the need for scale-up of Lean thinking in primary healthcare settings to address underperforming indicators.

Keywords: Lean thinking, cervical cancer screening, women living with HIV

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Cervical cancer is the second most common cancer among South African (SA) women, with 10 532 new cases in 2022 (17.9% of female cancer diagnoses), and higher prevalence among women living with HIV (WLWH).[1,2] WLWH have a six-fold greater risk of cervical cancer compared with HIV-negative women.[3] Cervical cancer screening (CCS), primarily through cytology, detects precancerous changes to prevent malignancy.[4] CCS can reduce mortality by up to 80%, and achieving 70% global coverage by 2030 may prevent 300 000 deaths.[5,6] However, SA's CCS rate remains low at 19.3%, particularly among WLWH.[7]

The AIDS Healthcare Foundation (AHF), a global non-governmental organisation, supports HIV/AIDS services at selected primary healthcare (PHC) facilities in SA. AHF launched the Cervical Cancer Screening Enhancement programme (CerviScreen) in June 2023, applying Lean thinking to improve CCS rates in selected PHC facilities in KwaZulu-Natal, Eastern Cape and (excluded from this analysis) Gauteng provinces. The 12-month average baseline CCS rates among WLWH of reproductive age, in the healthcare facilities supported by AHF, were 38% and 48% in Eastern Cape and KwaZulu-Natal, respectively.[8]

Quality improvement programmes (QIPs) are widely implemented in healthcare, yet their impact is not often evaluated.[9] Assessing such programmes provides valuable insights for service improvement and policy changes.[10] No prior research has focused on applying Lean thinking in PHC settings to improve CCS for women newly diagnosed with HIV. This study sought to evaluate the effect of Lean tools and techniques, via the CerviScreen programme, on CCS coverage among women of reproductive age who were newly diagnosed with HIV, over a 7-month period (1 October 2023 - 30 April 2024) at selected sites in Eastern Cape and KwaZulu-Natal, SA. The key objectives, reported in this manuscript, were to: (*i*) describe the CerviScreen programme and implementation process; and (*ii*) analyse the CCS rates among eligible women newly diagnosed with HIV at the participating PHC sites in the two provinces, and compare performance between the regions.

Lean-based quality improvement

Promoting continuous quality improvement (QI) nurtures an environment where perpetual learning, creativity and progress are encouraged. This typically takes the form of distinct QI approaches or models that utilise specific tools and methodologies designed for quality enhancement.[11] One such approach is Lean thinking or 'Lean'.

Lean is a management philosophy that originated in the automobile manufacturing industry, and consists of principles and practices

aimed at improving efficiency and quality of work by reducing or eliminating waste in an organisation.[12,13] Lean uses continuous improvement through unique problem-solving and decision-making tools and techniques, of which those of key relevance to the study are described below.[13]

PDCA cycle

The four-step 'plan, do, check and act' (PDCA) cycle, further subdivided into nine steps (Appendix Fig. S1), is applied iteratively to progressively improve performance through the application of Lean tools and techniques. The PDCA cycle serves as a stepwise process, guiding a QI team on assessing the problem, identifying root causes and determining a plan of action, monitoring and evaluating the influence of these actions and then appropriately responding to the outcome.

A3 tool

This is a template on which key discussions and activities from the PDCA cycle are recorded in team meetings. The improvement processes are documented on an A3-sized sheet of paper that is divided into two sections: on the left-hand side, the problem background is described, key indicators are monitored and root-cause analysis is performed, and on the right-hand side, the team records proposed solutions and an action plan, and evaluates progress (Appendix Fig. S2).[14]

The fish-bone diagram and 5 whys technique

A fishbone diagram is a visual tool that illustrates the connections between different factors contributing to a specific effect or problem, resembling the skeleton of a fish.[15] The 'head' of the fishbone represents the main problem being addressed, while the long bones extending from the spine illustrate the primary cause categories (typically related to 'man' or people, 'method', 'material' and 'machine') that contribute to the issue.[15] The tool is often used in conjunction with the '5 whys' technique to pinpoint the root cause of an issue.[16] The 5 whys technique involves repeatedly asking 'why' whenever a problem arises, in order to move past the surface-level symptoms and uncover the root cause.[17]

Pareto analysis

The Pareto principle, commonly referred to as the 80/20 rule, posits that ~80% of outcomes arise from 20% of contributing factors. This principle underscores the importance of prioritisation, suggesting that focusing efforts on the most impactful tasks or causes can yield significant results. By channelling attention toward the most significant contributors, the principle facilitates problem-solving and efficiency.[18] The Pareto principle applied in practice results in what is known as the Pareto analysis (Appendix Fig. S3).[19,20]

The above-described Lean tools and techniques are pertinent to this study, as they were implemented within the CerviScreen programme. The detailed practical application of these tools and techniques is elaborated upon in subsequent sections.

Methods

Design

This quantitative study employed a controlled before-and-after design to retrospectively evaluate the change in CCS coverage at Eastern Cape and KwaZulu-Natal PHC sites where the CerviScreen QIP was implemented (QIP sites). Each QIP site was matched with control PHC sites, where the programme was not implemented, in terms of the total number of adult female clients of reproductive age (15 - 49 years) who were newly diagnosed with HIV (CCS workload demand). The QIP addresses systemic inefficiencies and resource constraints. As such, clinics were not matched based on resource availability or staff-to-patient ratios, given that these factors were expected to vary throughout the implementation period, and could potentially confound the results. In contrast, patient demand was not influenced by the intervention or by clinic catchment areas, which are unlikely to confound the CCS performance within the clinics.

Setting

The study was conducted in the Amathole and eThekwini health districts, which are located in the provinces of Eastern Cape and KwaZulu-Natal, respectively. The target population included 143 PHC clinics in the Amathole health district, and 5 community health centres and 118 PHC clinics in the eThekwini health district.

Participants

Non-probability purposive sampling was used to select the AHF-supported QIP sites. Control sites, also supported by AHF, were then purposively selected by attempting to match, as closely as possible, each of their monthly total number of females of reproductive age who were newly diagnosed with HIV with those of the QIP sites. Eighteen QIP sites were selected from Eastern Cape and KwaZulu-Natal (nine from each province). An equal number of control sites was selected for each province.

Data collection

Site-specific data for both provinces were extracted from serial A3 tools onto an Excel (Microsoft, USA) spreadsheet template over the data collection period (1 October 2023 - 30 April 2024), and analysed using Stata/SE version 18 (StataCorp, USA).

Ethical considerations

Research ethical approval was obtained from the SA Medical Association Research Ethics Committee (SAMAREC) (ref. no. 280808016/039/2024). Gatekeeper permission was obtained from the KwaZulu-Natal Department of Health's provincial health research and knowledge management unit, the eThekwini and Amathole district health offices and the eThekwini municipality health unit.

Results

Table 1[21] reflects the 18 QIP and 18 control sites with their baseline CCS coverage and monthly average number of females newly diagnosed with HIV (as of September 2022). Clinics have been anonymised to maintain confidentiality. Seventeen and 24 sites were supported by AHF in Eastern Cape and KwaZulu-Natal provinces, respectively, at the time of the study, but baseline CCS data for some sites are not reflected as they were not previously supported by AHF. Thus there were no baseline CCS data available for these sites from the AHF Annual Quality Benchmark Report 2021 - 2022.

CerviScreen implementation process

Embedded in Lean thinking, the PDCA cycle was adopted as the QI model for implementing CerviScreen. The QIP focused on the adoption of some of the tools and techniques from the Lean toolbox, but did not rely on the five Lean principles to guide its implementation. Table 2 presents a summary of the QIP activities conducted in accordance with each of the nine action steps. In step 2, nine QIP sites were selected in each of the two provinces, after applying a Pareto analysis to baseline data.

Pareto analyses for site selection were conducted at baseline. The Pareto analysis template and an example of an analysis conducted for

Table 1. Sites included in the study, with baseline CCS coverage and average numbers of females of reproductive age who were newly diagnosed with HIV

QIP sites				Control sites			
Subdistrict	Site name	Baseline CCS coverage, %	Females of reproductive age newly diagnosed with HIV, monthly average, *n*	Subdistrict	Site name	Baseline CCS coverage, %	Females of reproductive age newly diagnosed with HIV, monthly average, *n*
KwaZulu-Natal							
North	KZN9	0	14	West	KZN11	38	15
North	KZN5	15	29	South	KZN1	100	29
South	KZN8	0	8	West	KZN16	100	8
South	KZN13	0	18	North	KZN4	99	17
South	KZN14	11	16	North	KZN17	98	17
South	KZN7	17	13	North	KZN6	64	11
South	KZN12	0	1	West	KZN20	100	7
South	KZN2	0	21	North	KZN19	100	21
South	KZN3	2	14	South	KZN15	30	14
Eastern Cape							
Mbhashe	EC2	24	11	Mnquma	EC14	63	7
Mbhashe	EC9	29	11	Mnquma	EC16	-	15
Mbhashe	EC8	43	4	Mbhashe	EC3	46	3
Mbhashe	EC4	45	2	Mnquma	EC12	50	2
Mbhashe	EC5	28	10	Mnquma	EC16	-	15
Mnquma	EC10	0	7	Mbhashe	EC12	50	2
Mnquma	EC15	0	4	Mbhashe	EC6	80	5
Mnquma	EC13	0	6	Mnquma	EC11	73	3
Raymond Mhlaba	EC1	22	6	Mnquma	EC17	-	6

CCS = cervical cancer screening; QIP = quality improvement programme.
Source: Clinic patient registers.[21]

Table 2. QIP application of the nine action steps within the PDCA cycle

Step number	Description	CerviScreen activities
1	Select improvement opportunity	The goal was to improve the proportion of CCS among women aged 15 - 49 years who were newly diagnosed with HIV. Objectives, indicators and targets were established.
2	Analyse current situation or process	CCS coverage data of all supported clinics in each region were analysed. Gaps were identified and Pareto analyses were conducted for site selection.
3	Identify root causes	For each province, root cause analysis was conducted using a fish-bone diagram. Root causes were sought by applying the 5 whys technique. Subsequently, a list of identified problems was developed from the established root causes.
4	Generate and choose solutions	Brainstorming was applied to generate ideas for solving the identified problems. These ideas were shortlisted and further refined into practical interventions and activities.
5	Map out and implement action plan	The list of solutions was converted into an initial action plan, with each activity assigned responsible person(s) and time frames.
6	Analyse the results	The QIP team assembled monthly to review progress in implementation of the initial action plan. The most recent data for each of the indicators were reviewed, and root-cause analysis was repeated on the underperforming indicators at QIP sites.
7	Draw conclusions	From the performance review and root-cause analysis, conclusions were drawn. Trends were analysed and priority QIP sites were isolated for targeted interventions.
8	Adopt, adapt or abandon	The previous step paved the way for the generation of specific solutions and the development of a new action plan. Interventions that were not working were either modified or abandoned, while those that worked were formally adopted.
9	Monitor	Deliberations at every QIP follow-up meeting were documented on A3 tools. The PDCA cycle was repeated using the A3 tool as a structural guide and record-keeping tool.

QIP = quality improvement programme; PDCA = plan, do, study/check and act; CerviScreen = Cervical Cancer Screening Enhancement programme; CCS = cervical cancer screening.

Eastern Cape clinics are shown in Appendix Fig. S3.

Common observations from the application of the A3 tool included the following:

- Collaborative brainstorming with a multidisciplinary team of healthcare professionals during follow-up QIP meetings enhanced the depth and accuracy of root-cause analyses, while also generating a broader range of problem-solving strategies.
- Implementation of targeted, small-scale interventions led to rapid and measurable improvements in specific performance indicators.
- Prompt escalation and reporting of A3 tool findings to senior management facilitated greater engagement and buy-in from key decision-makers.

Root-cause analyses and interventions applied

A series of root-cause analyses was conducted in each province at baseline and during subsequent QIP follow-up meetings. An example of an initial completed fishbone diagram is shown in Appendix Fig. S4. Findings emerging from the root-cause analysis included limited provider skills and knowledge, staffing constraints, inefficient client flow through clinics, leading to missed screening opportunities, inadequate record-keeping, resulting in under-reporting of completed CCS, and insufficient space and materials to perform the procedure.

Interventions addressing root causes identified during QIP meetings were instrumental in achieving the objectives set by the QIP teams. In facilities with inefficient patient flow, patient flow mapping was conducted to identify bottlenecks and streamline movement through the clinic, thereby reducing missed opportunities for CCS. A key intervention applied at some of the QIP sites, where supported by clinic management, involved establishing centralised CCS service points. This enabled the routing of patients to a dedicated, fully equipped room where a clinician could offer, perform and document CCS in one room. Designated clinicians served as 'CCS champions', tasked with promoting and enhancing CCS coverage within their respective facilities. Supplementation of essential CCS materials – such as vaginal specula and examination lights – to clinics experiencing shortages facilitated rapid service improvements. Furthermore, the development and implementation of a standard operating procedure (SOP) for CCS record-keeping and data management addressed under-reporting issues. Complementary training for clinicians on CCS guidelines and for data capturers on the SOP improved overall CCS awareness, and strengthened documentation practices.

Analysis of CCS rates at QIP and control sites

The results of the analysis are divided into three notable areas: (*i*) CCS performance trend; (*ii*) CCS performance at QIP and control sites; and (*iii*) comparison of QIP site CSS performance between KwaZulu-Natal and Eastern Cape.

CCS performance trend

For both provinces included in the study, a one-way repeated measures analysis of variance (ANOVA) was conducted to determine whether the proportion of eligible women screened for cervical cancer changed over time. There was a statistically significant change in performance over the study period at QIP sites in KwaZulu-Natal (F=8.336, $p<0.001$) and Eastern Cape (F=15.525, $p<0.001$) during the implementation of the QIP.

Figs 1 and 2 demonstrate the gradual and consistent increase of the average proportion of eligible women screened for cervical cancer over time in KwaZulu-Natal and Eastern Cape QIP sites.

CCS performance at QIP and control sites

Screening performance at control sites was analysed in comparison with QIP site performance. Applying a two-way repeated measures ANOVA test demonstrated that there was no statistically significant difference in the change in proportion of eligible women screened for cervical cancer over time between QIP and control clinics in KwaZulu-Natal (F=0.022, $p=0.884$) and Eastern Cape (F=0.882, $p=0.362$). Appendix Figs S5 and S6 depict the average proportion of eligible women screened for cervical cancer in QIP and control clinics over time in KwaZulu-Natal and Eastern Cape, respectively.

Comparison of KwaZulu-Natal and Eastern Cape QIP site screening performance

A two-way repeated measures ANOVA test was conducted to determine if there was any difference in the change of percentage of screened women over time between KwaZulu-Natal and Eastern Cape QIP sites. The results show a statistically significant difference (F=11.12, $p=0.004$). Therefore the average change of proportion of screened women over time was not the same in the two provinces. The average change of proportion of screened women for both provinces is reflected in Fig. 3.

Discussion

CCS coverage at QIP sites in both provinces rose sharply during the first 2 months of implementation, stabilising by month 7. This rapid progress stemmed from

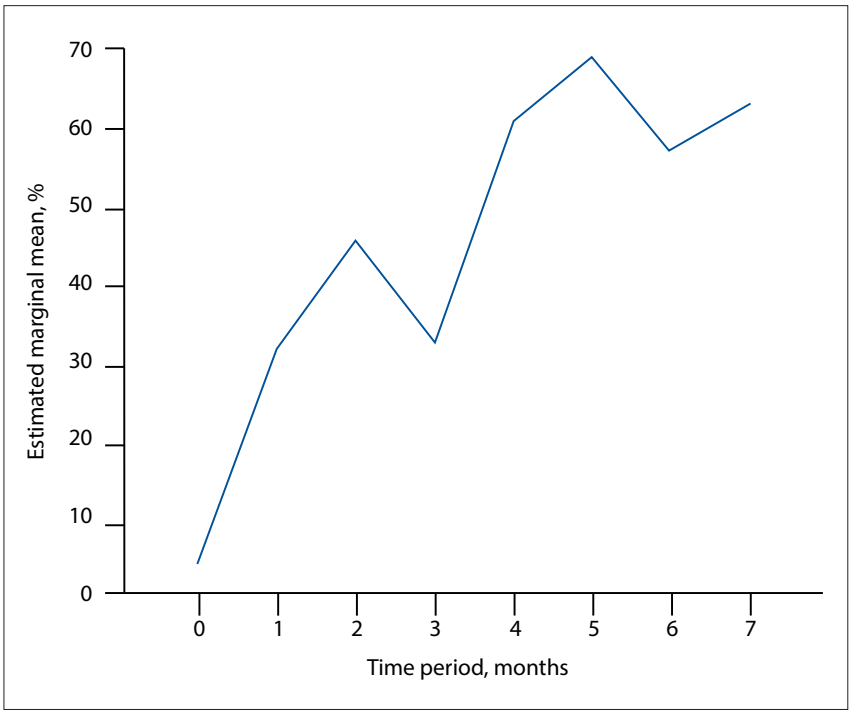

Fig. 1. Estimated marginal means of eligible women screened for cervical cancer in KwaZulu-Natal Province over a 7-month period.

comprehensive CerviScreen training on Lean tools, which prioritise redesigning care delivery processes.[22,23] Baseline assessments identified gaps and quick wins, enabling the introduction of simple, non-bureaucratic measures within the first 2 months. Centralised record-keeping of CCS further accelerated improvements.

Intermittent troughs in performance are not unexpected when a QIP is implemented in a fickle environment consisting of a 'bewildering array of value-concepts, reflected in a plethora of quality measures and frameworks'.[24] When Lean is applied in healthcare, value is not perceived as an individual attribute, but rather as a characteristic of the entire system.[22] Such a system is subject to unpredictable whims such as employee absenteeism, fluctuating patient inflows, changes in policies and leadership, and external events such as inclement weather and civil unrest.

QIPs in healthcare often achieve early successes, but sustaining these gains and preventing reversion to previous systems remain challenging.[25] After addressing initial low-hanging fruit, subsequent progress slows as remaining issues become more complex. Resistance to change, resource constraints and shifting priorities further impede improvement.[26] Strong project leadership by individuals with a vested interest in achieving the set goals and the ability to inspire and motivate QIP members may thwart such failures. Furthermore, gaining the support of key stakeholders and management at the outset is vital to ensure project longevity.

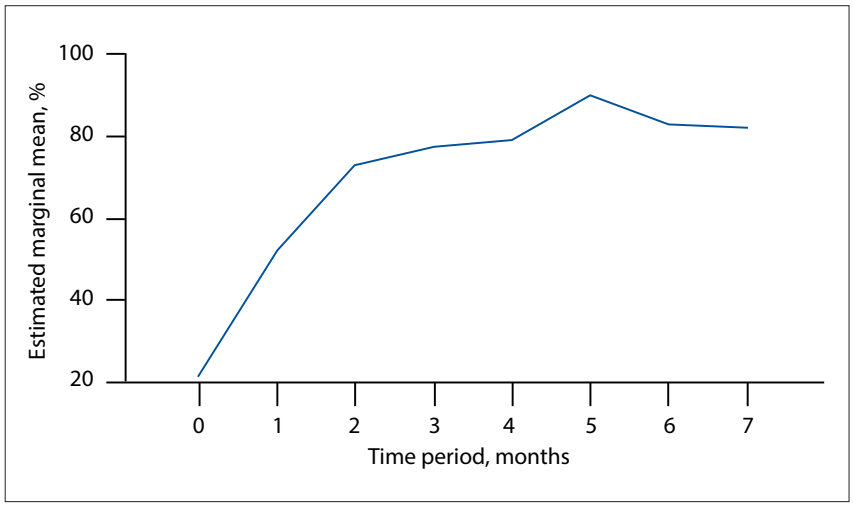

Fig. 2. Estimated marginal means of eligible women screened for cervical cancer in Eastern Cape Province over a 7-month period.

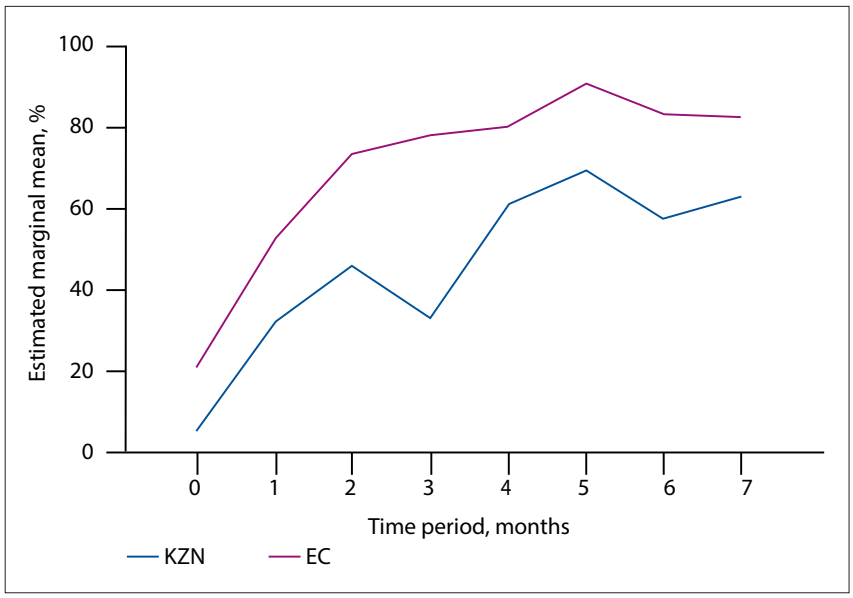

Fig. 3. Estimated marginal means of eligible women screened at quality improvement programme (QIP) sites in Eastern Cape (EC) and KwaZulu-Natal (KZN) provinces over a 7-month QIP implementation period.

The relatively stable performance of control sites is likely due to their consistent baseline processes. These sites were not subjected to new interventions, implying that their operational routines continued without disruption, limiting their potential for significant improvement over time. By contrast, the incremental improvements observed at QIP sites reflect the integration of Lean thinking, such as enhancing process efficiency and optimising value streams.[13] Once staff at QIP sites adapted to new workflows and processes, their performance began to surpass that of control sites, demonstrating the potential of Lean-based QIPs to deliver sustainable gains in CCS rates.

The comparative analysis of screening performance between the two provinces showed a statistically significant difference in CCS coverage over time. This can be attributed to a combination of factors. Variation can be explained by the dissimilarity in provincial context, which is described as the environment, setting, location and factors surrounding QIP implementation efforts.[27] The environment includes physical infrastructure, availability of equipment and clinic layout, all of which can affect the efficiency of CCS delivery. The setting – whether the clinic is urban, peri-urban or rural – may affect access challenges, such as keeping to a clinic appointment for a Pap smear. Location describes geographical accessibility, proximity to referral hospitals and transport networks. The magnitude and concentration of the population in eThekwini district in KwaZulu-Natal, compared with the Eastern Cape, may add strain to the limited resources at PHC clinics, which may partially explain the lower screening rates in KwaZulu-Natal QIP sites. These interprovincial contextual disparities can be further disaggregated by social determinants of health, resource allocation for health services and access to healthcare across provinces, all of which may explain CCS coverage differences across provinces.[28-30]

The consistent improvement in screening rates observed in both provinces over time demonstrates the effects of applying Lean thinking to health programmes. However, Lean implementation did suffer impediments along the way, as seen by some of the troughs in the performance trend.[31]

The limited duration of the observation period necessitates cautious interpretation of the trend analysis, while the lack of more precise clinic matching may introduce confounding factors. These factors are

acknowledged as study limitations, and accordingly, the findings should be interpreted with care.

Conclusion

The value of this study rests on two premises: (*i*) it delivers an outline of the methodology applied in the practical implementation of a novel quality improvement approach to addressing a typical underperforming service within a PHC context; and (*ii*) it assesses the outcomes of the QIP derived from this approach.

The PDCA methodology and nine steps provided essential guidance for PHC managers addressing underperforming health indicators. Fluctuating QIP performance trends are expected in facilities affected by factors such as absenteeism, patient inflow variability, policy shifts, leadership changes and external disruptions. Strong project leadership, initial management support and regular progress updates are crucial for sustaining improvements and ensuring long-term success.

The initial lag in performance at QIP sites compared with control sites underscores the transitional challenges inherent in implementing Lean. Interprovincial disparity in CCS performance is likely the result of contextual differences and human resource capabilities, supply and demand factors such as health resource allocation, and population size and spread across rural and urban areas.

Future research should prioritise longitudinal studies to evaluate the long-term sustainability of the Lean approach in CCS programmes, especially in resource-limited settings. Comparative studies across provinces and healthcare contexts should also explore factors such as leadership, worker training, resource allocation, community involvement and patient perceptions to guide tailored quality improvement approaches.[27]

Declaration. None.

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Author contributions. LN co-ordinated the manuscript drafting, consolidated the results section and inputs from co-authors, and contributed to information on Lean and quality improvement. TY-S and SN equally contributed to the literature review, discussion and overall review of the manuscript.

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