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Visual Inspection with Acetic Acid (VIA) Versus Visual Inspection with Lugol's Iodine (VILI) for Cervical Cancer Screening in Rural Settings: A Comprehensive Review

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ABSTRACT

Cervical cancer disproportionately affects women in rural low- and middle-income countries (LMICs), where access to cytology, colposcopy, and follow-up care is limited. Visual inspection with acetic acid (VIA) and visual inspection with Lugol's iodine (VILI) are low-cost tests that provide immediate results and can be used within single-visit "screen-and-treat" models delivered by trained non-physician providers. This narrative review synthesizes global guidance and empirical evidence—diagnostic accuracy, programmatic effectiveness, cost, and practical implementation—comparing VIA and VILI in rural set-ups. Meta-analyses and head-to-head cross-sectional studies indicate that both methods have moderate accuracy for detecting CIN2+, with several analyses showing higher pooled sensitivity for VILI than VIA at roughly similar specificity [4,5]. Randomized and cluster-randomized trials demonstrate population-level benefits of visual screening when programs ensure treatment linkages; however, contemporary WHO recommendations prioritize primary HPV testing, using VIA (and, where available, VILI) mainly for triage or as interim options during HPV scale-up [1,2]. Overall, the choice between VIA and VILI matters less than investment in training, quality assurance (QA), procurement reliability, and same-day ablative treatment access. We conclude with a pragmatic algorithm tailored to rural programs, emphasizing phased HPV integration, VIA/VILI triage, and monitoring of overtreatment alongside equity and acceptability considerations [1,8–11].

Keywords: *cervical cancer screening; VIA; VILI; rural health; LMIC; screen-and-treat; thermal ablation; HPV*

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1. INTRODUCTION

Globally, cervical cancer remains a major cause of preventable morbidity and mortality, with the burden concentrated in LMICs and among women living in rural and peri-urban communities. Resource constraints—limited laboratories, few colposcopy units, travel costs, and loss-to-follow-up—attenuate the impact of cytology-based programs. In response, the World Health Organization (WHO) has shifted guidance toward HPV-primary screening and single-visit pathways with ablative treatment, while recognizing VIA as a practical triage or fallback where HPV assays are not yet feasible [1]. A 2024 WHO update further introduced dual-stain (p16/Ki-67) cytology as a triage option for HPV-positive women, reflecting a broader move toward risk-stratified, fewer-visit care [2]. Within this evolving policy context, VIA and VILI still play pivotal roles in rural set-ups by enabling immediate decisions with minimal infrastructure [3]. This review compares VIA and VILI on diagnostic accuracy, determinants of performance, outcomes in randomized and implementation studies, costs, and operational considerations specific to rural programs.

2. METHODS

We conducted a narrative review of guidelines (WHO 2021 and 2024), training manuals (IARC Technical Publication No. 41), systematic reviews/meta-analyses, randomized and cluster-randomized trials, large cross-sectional accuracy studies, and rural program reports. Search terms included "VIA," "VILI," "visual inspection," "cervical screening," "rural," "LMIC," "screen-and-treat," "thermal ablation," and "HPV triage." Particular attention was paid to head-to-head VIA versus VILI evaluations and studies from India and sub-Saharan Africa [1–5,8,10–12,14–16]. Given heterogeneity in verification standards and definitions, we highlight studies with colposcopy/biopsy applied broadly and interpret pooled estimates alongside context-specific determinants of performance.

3. PRINCIPLES AND PROCEDURES OF VIA AND VILI

VIA involves applying 3–5% acetic acid to the cervix and inspecting, under adequate light, for acetowhite changes that correspond to areas with increased nuclear density and protein coagulation. VILI applies Lugol's iodine, which stains glycogen-containing normal squamous epithelium brown/black, while glycogen-depleted neoplastic epithelium remains mustard-yellow. Both tests yield results within minutes, require a speculum, light source, and low-cost reagents, and can be performed by trained nurses or midwives. IARC's manual defines positivity thresholds and provides job aids and algorithms that underpin standardized training and QA in rural programs [3]. Contraindications to iodine are uncommon but must be screened; inflammation, bleeding, and pregnancy may complicate interpretation. The immediate-result nature of both tests enables same-day linkage to ablative therapy, a crucial advantage where return visits are difficult [1,3].

4. DIAGNOSTIC ACCURACY: VIA VERSUS VILI

a. Meta-analyses and pooled estimates

A BMJ diagnostic-test meta-analysis synthesizing sub-Saharan African studies (n≈61,381 VIA; n≈46,435 VILI) reported higher pooled sensitivity for VILI than VIA when the reference standard was applied to all women (VILI sensitivity 95.1% [90.1–97.7%] vs VIA 82.4% [76.3–87.3%]), with similar pooled specificities (VILI 87.2% [78.1–92.8%] vs VIA 87.4% [77.1–93.4%]) [4]. These findings suggest that, where supply and training permit, VILI can improve detection of CIN2+ compared with VIA without a major specificity penalty. Other syntheses corroborate moderate accuracy for both tests and emphasize verification bias, operator variability, and positivity thresholds as key drivers of heterogeneity [4,12].

Test	Pooled Sensitivity for CIN2+ (95% CI)	Pooled Specificity (95% CI)
VIA	82.4% (76.3–87.3%)	87.4% (77.1–93.4%)
VILI	95.1% (90.1–97.7%)	87.2% (78.1–92.8%)

Source: Fokom-Domgue et al., BMJ 2015 [4].

b. Head-to-head accuracy studies

In Kerala, India (n=4,444), Sankaranarayanan et al. compared low-threshold VIA, high-threshold VIA, VILI, and cytology with colposcopy/biopsy verification in all women. Sensitivities for CIN2+ were 88.6% (low-threshold VIA), 82.6% (high-threshold VIA), and 87.2% (VILI) with specificities 78.0%, 86.5%, and 84.7%, respectively—indicating VILI's sensitivity matched or exceeded VIA at comparable specificity [5]. Trials and program studies in Latin America and Africa (e.g., LAMS partial results) broadly show VILI's sensitivity advantage with variable specificity, recognizing setting-specific factors [15,19].

c. Subgroups and special contexts

Among women living with HIV, a randomized trial from western Kenya found similar overall accuracy of VIA and VILI, with a trend toward higher CIN2+ detection in VILI but trade-offs in specificity—highlighting the need for tailored protocols in immunocompromised populations [20]. Inter-observer variation and cervicitis can inflate VIA/VILI positivity and reduce specificity; programs should integrate STI management and defer screening during active inflammation [13,14].

5. HEALTH IMPACT AND PROGRAMMATIC OUTCOMES

Evidence from randomized and cluster-randomized trials demonstrates that visual screening can produce population-level gains when paired with effective treatment linkages. In South Africa, a JAMA randomized trial of "screen-and-treat" demonstrated reductions in CIN2+ with both HPV-based and VIA-based strategies versus delayed evaluation [8]. In Mumbai, four rounds of VIA delivered by primary health workers achieved a 31% reduction in cervical cancer mortality compared with control, underscoring the value of community-embedded screening with accessible triage and treatment [6].

In rural India (Osmanabad), a single round of HPV testing reduced advanced cancers and deaths more than VIA, supporting WHO's pivot toward HPV-primary where feasible [7].

6. DETERMINANTS OF TEST PERFORMANCE IN RURAL PROGRAMS

Performance of visual tests depends strongly on training, QA, and clinical context. IARC's manual provides standardized criteria and images that improve inter-rater consistency; routine mentorship, periodic re-certification, and use of checklists/job aids are recommended [3]. Nurse-led programs can achieve acceptable accuracy, but inter-observer variability is well documented and must be actively managed [13]. Cervical inflammation, parity, and age influence VIA/VILI positivity, and inflammation is a consistent predictor of false-positive VIA [14]. Digital cervicography (smartphone image capture) supports supervision and feedback; a meta-analysis suggests moderate accuracy benefits for detecting CIN2+ among HPV-positive women, though workflow integration is key [12].

7. TREATMENT LINKAGES: FROM CRYOTHERAPY TO THERMAL ABLATION

Single-visit screen-and-treat success rests on reliable access to ablative treatment. WHO's 2019 guideline introduced thermal ablation (TA) as an alternative to cryotherapy for ablation-eligible lesions, with advantages in portability, lack of gas supply dependency, and ease of use in outreach clinics [9–11]. Pilot randomized comparisons suggest TA achieves treatment success comparable to cryotherapy without cryo's logistical downsides; emerging trials of portable TA devices aim to confirm non-inferiority to excisional methods in screen-and-treat programs [10,11,21].

8. COST, LOGISTICS, AND RURAL FEASIBILITY

Visual screening remains among the lowest-cost options per woman screened, with VIA/VILI tests costing a few US dollars, whereas cytology and HPV assays cost more and require laboratory infrastructure. Economic models consistently find that strategies minimizing visits (screen-and-treat) yield better cost-effectiveness by reducing attrition; older multi-country analyses and newer program-based costing studies support this principle [7,16]. In women living with HIV, VIA/VILI are inexpensive but less sensitive than careHPV; however, the incremental cost per extra CIN2+ detected by adding VILI to VIA can be acceptable in some settings (e.g., US$48 per additional case detected vs VIA alone) [9]. For rural programs scaling HPV primary, VIA (or VILI) retains value as an on-site triage to determine ablation eligibility and reduce overtreatment [1,9,24,25].

9. OVERTREATMENT, TRIAGE STRATEGIES, AND RISK MANAGEMENT

Because visual tests have modest specificity and positive predictive value, same-day treatment after a single positive VIA/VILI inevitably entails overtreatment—treating some women without CIN2+. Modeling and implementation studies show overtreatment rates vary widely by prevalence, operator thresholds, and triage strategy; using HPV primary with VIA triage generally reduces overtreatment compared with HPV screen-and-treat alone in higher-prevalence settings [1,9,24,25]. Where HPV is not available, combining VIA with VILI as a "second look" can boost sensitivity but may also increase false positives; programs should adopt clear ablation-eligibility criteria and monitor positive predictive value and adverse events [4,5,10,11,19].

10. COMPARATIVE SYNTHESIS FOR RURAL SET-UPS

• Accuracy: VILI often shows higher sensitivity than VIA with similar specificity in rigorous evaluations, potentially improving CIN2+ detection where disease prevalence is meaningful and confirmatory testing is limited [4,5,15].
• Workflow and supplies: VIA is widely standardized and more familiar; VILI requires a consistent iodine supply and awareness of rare contraindications. Adding VILI as an adjunct to clarify equivocal VIA can help in first-round campaigns if time and training allow [3,15].

• Policy alignment: WHO recommends HPV primary wherever feasible, with VIA (and contextually VILI) as triage or interim options; a 2024 update introduces dual-stain cytology as an additional triage for HPV-positive women [1,2].
• Equity and access: In rural outreach, the immediate-result, low-infrastructure nature of visual methods supports single-visit pathways that minimize loss-to-follow-up—often the decisive factor for impact [6–9].

11. PRAGMATIC ALGORITHM FOR RURAL PROGRAMS

1. If HPV testing is available: offer HPV primary (self-sample where acceptable), triage HPV-positive women with VIA (or VILI where trained and available) to establish ablation eligibility, and consider dual-stain cytology in settings with LBC and lab access [1,2,24,25]
2. If HPV is not available: implement VIA as standard and consider VILI as a second look to enhance sensitivity during initial rounds; ensure access to thermal ablation and robust QA to limit false positives [3–5,9–11,15].

3. Quality systems: use IARC job aids, digital cervicography for feedback, and periodic re-certification; manage cervicitis/STIs and defer screening during active inflammation [3,12–14].
4. Monitor program indicators: positivity rates, treatment completion, adverse events, and—where feasible—histology on a subsample to estimate overtreatment and refine thresholds [1,7,9,24].

12. LIMITATIONS AND RESEARCH GAPS

Evidence is heterogeneous, with many accuracy studies subject to verification bias or variable thresholds. Head-to-head, adequately powered VIA-versus-VILI trials across diverse rural programs remain limited. Prospective evaluations of digital aids (smartphone imaging/AI) and of dual-stain triage in LMIC settings are needed. Implementation research should prioritize overtreatment mitigation while preserving access and same-day care [4,12,21,24,25].

13. CONCLUSION

In rural LMIC settings, both VIA and VILI remain practical, immediately actionable screening options that can be delivered by trained non-physician providers and linked to same-day ablation. Across meta-analyses and comparative studies, VILI tends to be more sensitive than VIA with similar specificity, though performance is highly context-dependent. Programs should align with WHO's trajectory toward HPV-primary screening, using VIA (and where feasible VILI) as triage or as interim strategies during scale-up, with dual-stain cytology as an option where laboratory capacity exists. Ultimately, outcomes depend less on the choice between VIA and VILI and more on investment in training, QA, and guaranteed access to safe, acceptable ablative treatment in a single visit [1–3,4–11].

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