

Economic Evaluations of Cervical Cancer Screening Methods: a Systematic Review

Thatohatsi Sefuthi (✉ tsefuthi@gmail.com)

Stellenbosch University - Tygerberg Campus: Stellenbosch University Faculty of Medicine and Health Sciences

<https://orcid.org/0000-0002-7738-2444>

Lungiswa Leonora Nkonki

Stellenbosch University - Tygerberg Campus: Stellenbosch University Faculty of Medicine and Health Sciences

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Abstract

Background: Cervical cancer screening is an important public health priority with the potential to improve the detection of pre-cancerous lesions in high-risk females for early intervention and disease prevention. Test performance and cost-effectiveness differs based on the specific screening method used across different platforms. There is a need to appraise existing economic evaluations of cervical cancer screening. The objective of the present systematic review was to identify primary and model-based economic evaluations of cervical cancer screening methods, and to provide a contextual summary of associated outcomes associated with screening modalities.

Methods: The review considered primary-based and model-based full economic evaluations of cervical cancer screening methods. Such evaluations methods include cost-effectiveness analysis, cost-utility analysis, cost-minimization analysis, cost-benefit analysis, and cost-consequence analysis. We searched the following databases for full economic evaluations of cancer screening methods globally: SCOPUS, Pubmed, National Health Economic Evaluation Database (NH EED), Cochrane, and Health Economic Evaluation Database (HEED). No date restrictions were applied. Model-based and primary-based full economic evaluations were included. A critical appraisal of included studies was performed by the main investigator, while a second independent reviewer assessed critical appraisal findings for any inconsistencies. Data were extracted using a standardized data extraction tool for economic evaluations. Data extracted from included studies were analysed and summarised to answer the study objective using the Joanna Briggs Institute (JBI) Dominance Ranking Matrix (DRM).

Results: Out of 671 screened studies, 44 met the study inclusion criteria. Forty-three studies were cost-effectiveness analyses while two studies reported cost-utilities of cervical cancer screening methods. HPV DNA testing was reported as a dominant standalone screening test by 14 studies, while 5 studies reported VIA as a dominant standalone screening test. Primary HPV screening strategies were dominant in 21 studies, while three studies reported Cytology-based screening strategies as the dominant screening method.

Conclusions: Evidence indicates that HPV-based and VIA testing strategies are cost-effective, but this is influenced by setting. Our review suggests the limited cost-effectiveness of cytology-based testing, which may be due in part to the need for specific infrastructures and human resources.

Systematic Review Prospero Registration: CRD42020212454. The review protocol may also be found on Prospero.

1. Introduction

Cervical cancer is a common form of malignancy and a leading cause of cancer-related mortality in females (1). It is also an important contributor to disease burden in Sub-Saharan Africa, with an estimated 75 000 new cases documented each year, as well as approximately 50 000 new deaths annually (2). The highest incidence of cervical cancer in the world is reported in Eswatini, with 6.5% of women developing the disease before the age of 75(3). Countries in Western, Middle, and Southern Africa are hardest hit by cervical cancer-related deaths, with world age standardised mortality rates (ASMR) of 23.0%, 21.1.%, and 20.0%, respectively (3). The economic burden of cervical cancer is also substantial. For example, Wu et al (2020) reported that, in the Henan province of China, costs associated with cervical cancer, from diagnosis to one year after discharge, ranged from \$8,066 to \$22,888 per patient (4).

Cervical cancer is caused by infection with high-risk serotypes of the Human Papilloma Virus (HPV) (5). Infection can lead to the development of pre-cancerous lesions and malignancy if left untreated (6). Since neoplastic transformation can take years or even decades to develop, early detection and treatment of pre-cancerous lesions provides an important opportunity for therapeutic intervention (7). Indeed, the World Health Organization (WHO) has identified cervical cancer as a potentially eliminable form of cancer (7). That being said, cervical cancer remains under-diagnosed in clinical settings, particularly for developing countries (8). Evidence however indicates that adequate screening is associated with reduction in cervical cancer-related deaths (9). The WHO estimates that prevention through vaccination, screening and early treatment, applying the 90-70-90 targets, could reduce median cervical cancer incidence rate by 10% by 2030 (10).

Several approaches have been developed to assist clinicians in screening for cervical cancer. These include unaided visual inspection with acetic acid (VIA) as well as assisted cytological (e.g. Papanicolaou (PAP) smear) and molecular (e.g. HPV DNA testing methods) (11)(12). A Pap test is a liquid cytology-based test in which cervix cells are analysed (13). Unaided VIA is carried

out by observing cervix cell colour changes in response to acetic acid exposure(14). These screening methods differ in terms of their diagnostic value, accuracy, and associated costs to the user and healthcare system (15).

Health economic evaluations (16) can help inform the clinical application and financing of appropriate screening methods for cervical cancer. Health economics research could ensure that the potential positive impact of health interventions are weighed against their use of limited resources particularly in lower- to middle-income healthcare settings (17). Economic evaluations might thus provide a possible framework to assist decision makers in providing much needed interventions based on available clinical evidence leveraged against the cost to the healthcare sector (18).

Several economic evaluations have examined the financial aspects of cervical cancer screening in resource-limited healthcare environments. Studies conducted in developing countries including India (19) and South Africa (20) suggest that the cost-effectiveness of individual modalities might differ based on setting. Findings from other studies conducted in developed nations such as Portugal (21) also support combining different screening methods depending on individual factors (21). This approach might however not be applicable in settings where health resources including access to molecular testing are already limited.

Health economic evaluations focused on cervical cancer screening are however limited by the use of different methodologies, and generalization across prior studies is often not possible. This highlights the need for a methodical approach to exploring systematic difference across various such economic evaluations conducted to date. At least three prior systematic reviews(22) have provided evidence supporting the cost-effectiveness of cervical cancer screening. However, Nahvijou et al (2014) limited their systematic review to cost-effectiveness analyses of cervical cancer screening methods (23). In 2015, Mendes et al (24) published a review whose aim was to identify mathematical models used to evaluate the impact of cervical cancer screening strategies. Though critical insights were gleaned from this review, restricting the study type to mathematical modelling resulted in the exclusion of primary-based economic evaluations. In their more recent review, Mezei et al. (2017) also limited their review to cost-effectiveness analyses, with a focus on lower- to middle-income countries. Furthermore, the authors selected only model-based economic evaluations (25). A large body of economic evaluation evidence is founded on randomized controlled trials and primary cost-effectiveness studies. Authors did not carry out an appraisal of the methodological quality of studies, which reduced the validity of the results. Lastly, authors focus on the cost-effectiveness of screening methods. This review builds on findings by Nahvijou et al (2014), Mendes et al (2015) and Mezei et al (2017), by reviewing all full economic evaluation methods including cost-utility, cost-benefit, cost-minimization, and cost-consequence analysis.

The aim of the present systematic review was to appraise the evidence on full economic evaluations of cervical cancer screening methods for improving pre-cancerous lesion detection in women from the payer and/ societal perspectives.

2. Methods

2.1. Research design

The present review of studies examining the economic evaluation of cervical cancer screening methods was conducted using the Joanna Briggs Institute methodology for systematic reviews of economic evaluation evidence (26).

2.2. Selection criteria

This review focused on primary- and model-based full economic evaluations of cervical cancer screening methods. Inclusion criteria were: 1) studies published in English, 2) studies which considered female patients screened for cervical cancer using visual (VIA), cytological (Papanicolou smear) or molecular (HPV DNA testing) methods. Exclusion criteria were: 1) studies not available in English, 2) other systematic reviews and meta-analyses. No date restrictions were applied. Exclusion criteria were: full-text studies not available or not published in English, 2) systematic reviews and meta-analysis

2.3. Outcomes

Full economic evaluation methods of interest included cost-effectiveness (CEA), cost-utilities (CUA), cost-benefit (CBA), cost-minimization and cost-consequence (CC). Measures of interest included ICERS of cost/year lives saved (YLS), cost/death averted, cost/CIN2 detected, cost/QALY gained, cost/life-year (LY), marginal cost/case detected, cost/life year gained (LYG). Since the focus was on economic evaluations of global screening methods, there were no specific socio-demographic or cultural factors considered

as outcomes of interest. Incremental cost-effectiveness ratios (ICERs) were converted to international dollars using a base year of 2020. Original costs were converted to the local currency of the study market using market exchange rate data(27). Adjustment for inflation was carried out by multiplying ICERs by a GDP deflator, which were obtained from the World Bank.

2.4. Search strategy

The selection of suitable studies and the procedures for their identification was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (26). The main investigator (TS) performed a formal search of the academic literature over a 5-month period (September 2020 – September 2021) using the following databases: SCOPUS, Pubmed, National Health Economic Evaluation Database (NH EED), Cochrane, and Health Economic Evaluation Database (HEED). All searches and screening of suitable studies were duplicated by another researcher to ensure unanimous selection of appropriate economic evaluations for this review. The search terms and all logical synonyms and iterations thereof depending on the database used are summarized in Appendix I. The reference lists of selected studies were also screened for the identification of article citations of possible interest for the present research. All relevant citations identified using these criteria were then collated and uploaded into a Microsoft Excel template and duplicates removed. Titles and abstracts were then screened by two independent researchers. The full text versions of eligible studies were assessed. The reasons for exclusion of studies were also documented and reported. The methodological quality of suitable studies was then assessed using the JBI standardized critical appraisal instrument (26) as well as the Drummond's checklist for assessing economic evaluations (18). Model-based studies were appraised using a model assessment checklist (28).

Figure 2 details Phillip et al checklist, which was used to assess model-based studies.

2.5. Data Extraction and Synthesis

All studies selected for inclusion underwent data extraction and synthesis (to the furthest extent possible), regardless of their methodological quality. Data were extracted from studies selected for inclusion in the review using the standardized data extraction tool from JBI SUMARI by one reviewer. A second independent reviewer assessed extracted data for inconsistencies and discrepancies. The JBI SUMARI tool was augmented by a data extraction tool developed by Wijnen et al. (29). Extracted information were: 1) descriptive data about cervical cancer screening studies including, research perspective, geographical setting, population characteristics, and methods, 2) measures for CEA, CUA, CB and CC, 3) conclusions about factors which drive (impede) the cost-effectiveness of cervical cancer screening.

Extracted data were then analysed and summarized using the JBI Dominance Ranking Matrix (DRM) (ref). This tool measures three potential outcomes for the cost of an intervention of interest against the health outcome(s) of interest, i.e. a) strong dominance (characterized by decisions distinctly favouring either the intervention or comparator, from a cost or clinical effectiveness standpoint), b) weak dominance (data favours either costs or effectiveness), and c) non-dominance (characterized by a less effective or more costly intervention).

3. Results

3.1. Study inclusion

From a total of 671 titles and citations screened following removal of duplicates (n=16), 80 abstracts were screened, and 74 studies selected for full-text review (Figure 1). Following exclusion of ineligible studies, a total of 44 were included in this review.

3.2. Methodological Quality of Studies Selected for Inclusion in Review

The overall methodological quality was high, with most studies identifying all important and relevant cost outcomes, as well as using relevant types of sensitivity analyses (univariate, multivariate, probabilistic, deterministic). Model-based studies generally reported structural assumptions as well as cervical cancer states and pathways. In certain cases, cost and outcome measures were not credible (Campos et al., 2012; Vassilakos et al., 2018), while in others, the procedures for valuation of costs and outcomes were not clear (Campos et al., 2012, 2015), while in others still (n=5), it was uncertain whether adjustment for differential timing was performed. Several studies (n=, 7%) did not establish prior clinical effectiveness of screening, and two studies did not report

sensitivity analyses. All 44 studies were however included for review. Decision rules for inclusion and exclusion were not created and all studies, regardless of their methodological quality, underwent data extraction to the furthest extent possible.

3.3. Description of Studies Included in Review

From a total of 671 titles and citations screened following removal of duplicates (n=16), 80 abstracts were screened, and 74 studies selected for full-text screening. Following exclusion of ineligible studies (Figure 1), a total of 44 were included in this review. In general, studies that were excluded during full-text selection compared health technologies beyond the scope of the research question.

The final selection included 44 studies published in English between 2004 and 2021. The characteristics of these studies are summarized in Appendix IV. A total of 38 studies (88%) were model-based and thus focused on hypothetical female cohorts as eligible participants. Studies were conducted across different locations, including South Africa, India, Greece, Lebanon and Nicaragua. Though studies assumed varied names to characterise perspectives, perspectives can be broadly categorised into two modalities, namely, payer and societal perspectives. A total of 14 (33%) studies assumed a societal approach, while 18 (42%) used a payer perspective.

3.4. Economic Evaluation findings from Cost-Effectiveness Studies

The most common economic evaluations examined cost-effectiveness (n=43; 97%). VIA was reported as a dominant screening method in 5 studies, while HPV DNA testing was reported as dominant by 14 studies. No study reported Cytology testing as a dominant standalone screening technology. A total of 20 (45%) cost effectiveness studies reported singular screening methods as dominant, while 26 cost effectiveness studies reported screen and treat strategies as dominant. Table 1 summarizes dominant screening technologies reported by studies.

Table 1: Summary of dominant screening technology by study

Dominant Standalone Screening Technology			
Study	VIA	HPV DNA Testing	Cytology
Legood et al. 2005	X		
Xie et al. 2017	X		
Campos et al.2015	X		
Deroche et al.2015	X		
Chauhan et al 2020	X		
Shi et al.2011		X	
Campos et al.2015		X	
Sharma et al. 2016		X	
Kim et al.2005		X	
Cromwell et al 2021		X	
Campos et al 2015		X	
Termrungruenglert et al 2017		X	
Zhao et al 2019		X	
Gamboa et al 2018		X	
Jansen et al 2020		X	
Ma et al 2019		X	
Sroczyński et al 2010		X	
Goldie et al 2005		X	
Campos et al 2018		X	

Table 2 outlines cost-effectiveness outcome measures associated with dominant screening methods and strategies. Estimated outcomes were: ICERS of cost/year lives saved (YLS), cost/death averted, cost/CIN2 detected, cost/life-year (LY), marginal cost/case detected, cost/life year gained (LYG). Studies which analysed both cost-effectiveness and cost-utility included cost/QALY gained as an outcome measure. Costs were reported in international dollars, using a base year of 2020.

Table 2: Cost-effectiveness analyses results

Study	Dominant Screening Technology/Method	Outcome Measure	I\$(2020)
Legood et al. 2005	VIA	Cost/positive case detected	482.84
Xie et al. 2017	VIA	Cost/positive case detected	1,448.04
Campos et al.2015	VIA at LTFU 60%	Cost/YLS	311.94
	VIA at LTFU 40%	Cost/YLS	181.96
Deroche et al.2015	VIA	Cost/ positive case detected	13.67
Chauhan et al 2020	VIA	Cost/QALY gained	772.86
Shi et al.2011	Clinician provided careHPV@0.5pg/ml	Cost/YLS	2,879.31
Campos et al.2015	HPV DNA testing at LTFU 10%	Cost/YLS	233.95
Sharma et al. 2016	HPV DNA testing every 5 years	Cost/YLS	1,355,400.48
Kim et al.2005	HPV triage (in Netherlands)	Cost/YLS	4,596.13
	HPV triage (in France)	Cost/YLS	3,414.27
	HPV triage (Italy)	Cost/YLS	1,969.77
Cromwell et al 2021	HPV DNA testing every 4 years	Cost/CIN2 detected	
Campos et al 2015	CareHPV (cervical sampling) (in India)	Cost/YLS	138.76
	CareHPV (cervical sampling) (in Nicaragua)	Cost/YLS	3,744.45
	CareHPV (cervical sampling) (in Uganda)	Cost/YLS	8,930.80
Termrungruanglert et al 2017	hrHPV testing every 5 years	Cost/positive case detected	1,410.04
Zhao et al 2019	CareHPV DNA testing every 3 or 5 years	Cost/positive case detected	3,038.76
Gamboa et al 2018	HPV DNA testing every 5 years	Cost/YLS	3,119.19
Jansen et al 2020	hrHPV testing	Cost/YLG	13,578.30
	hrHPV testing	Cost/QALY gained	15,242.86
Ma et al 2019	HPV DNA testing every 5 years	Cost/YLS	7,690.48
	HPV DNA testing every 3 years	Cost/YLS	10,122.28
Sroczynski et al 2010	HPV DNA testing every 2 years	Cost/YLG	138,829.99
Goldie et al 2005	HPV DNA testing (in Kenya)	Cost/YLS	56,318.49
	HPV DNA testing (in India)	Cost/YLS	283.16
	HPV DNA testing (in Peru)	Cost/YLS	644.44
	HPV DNA testing (in South Africa)	Cost/YLS	744.64
	HPV DNA testing (in Thailand)	Cost/YLS	602.77

Study	Dominant Screening Technology/Method	Outcome Measure	I\$(2020)
Campos et al 2018	HPV DNA testing every two years	Cost/YLS	2,848.58
Study	Dominant Screening Strategy	Outcome Measure	I\$(2019)
de Kok et al. 2012	Primary HPV Screening	Not reported	
Campos et al. 2014	HPV-DNA screening every 5 years followed by Cryotherapy (Screen and treat).	Cost/YLS	21,511.43
Pista et al. 2019	HPV testing with HPV 16/18 genotyping and Cytology triage	Cost/CIN2 detected	17,403.27
Skroumpelos et al. 2019	Primary HPV16/18 genotyping every 3 years.	Cost/Death averted	1,637,776.08
Termrungruanglert et al. 2019	HPV Primary screening triage with p16/Ki-67	Cost/detected case	1,660.20
Vassilakos et al. 2019	Self-HPV testing followed by Pap testing	Cost/QALY gained	12,678.37
Campos et al.2018	HPV testing followed by Cryotherapy	Cost/YLS	13,924.77
Mezei et al.2018	Community based self-collected HPV DNA testing followed by VIA triage	Cost/YLS	10,673.49
Lew et al. 2018	HPV testing and HPV 16/18 genotyping every 5 years	Not reported	Not reported
Barre et al.2017	Primary HPV testing and HPV 16/18 genotyping every 5 years	Cost/LY	2,674.12
Campos et al.2017	HPV DNA testing followed by Cryotherapy	Cost/YLS	27,288.02
Jin et al. 2016	Primary HPV DNA testing followed by followed by Cytology for HPV positive women. Testing every 5 years.	Marginal cost/Case detected	170,305.76
Burger et al. 2012	Unvaccinated women: Cytology followed by switching to HPV testing at 34 every 4 years.	Cost/YLS	23,743.81
	Vaccinated women: Cytology followed by switching to HPV testing at 31, every 6 years.	Cost/YLS	65,500.18
Flores et al. 2010	Pap and Clinician-HPV test (30-80 years)	Not reported	
Sroczyński et al.2011	HPV triage,1 year, Age: 30 years; prior Pap, 1 year	Cost/LYG	222,752.67
Kim et al.2005	UK: Combination testing, 5 years	Cost/YLS	
Sherlaw-Johnson	HPV Triage with LBC, 5 years	Cost/YLS	6,324.82
	Primary HPV with LBC, 5 years	Cost/YLS	7,671.45
	Combined Cytology and HPV with LBC, 5 years	Cost/YLS	46,663.86
	Combined cytology with LBC, 3 years	Cost/YLS	780,481.31
Chow et al.2010	HPV testing followed by Pap smear triage every 5 years	Cost/QALY gained	2,940.98
Campos et al. 2012	Primary HPV based testing strategies	Cost/YLS	584.88
Beal et al 2014	hrHPV with molecular triage	Cost/prevented missed case	580.76

Study	Dominant Screening Technology/Method	Outcome Measure	I\$(2020)
Tantitamit et al 2019	HPV genotyping with reflex dual stain cytology	Cost/QALY gained	837.20
Vale et al 2021	hrHPV testing with LBC triage	Cost/ Detection of CIN2/3	36.26
Berkhof et al 2010	HPV DNA testing every 5 years with Cytology triage	Cost/QALY gained	25,783.00
Vanni et al 2011	HPV DNA testing followed by Cytology triage every year	Cost/YLS	770.83
Lew et al 2016	5-yearly HPV screening with partial genotyping for HPV16/18 and referral to colposcopy, and cytological triage of other oncogenic types.	Not reported	X
Felix et al.2016	Co-testing using LBC and HPV 16 18/45genotyping	Cost/QALY gained	2,550.16

3.5. Economic Evaluation findings from Cost-Utility Studies

In total, only two studies examined cost-utility (Guerrero et al., 2015; Zhao et al., 2019). Guerrero et al., (30) compared VIA to Pap smear screening implemented along or in conjunction with HPV vaccination, at different coverages. Measures of outcome were ICERS in the form of cost/QALY gained and reduction in cervical cancer. In various coverage scenario analyses, VIA was associated with the highest dominance and cost saving, with ICERS ranging from dominant to 1443 USD. VIA augmented by HPV vaccination of pre-adolescent girls was reported to be dominant at coverage of 80%; with an ICER of 783 USD. Zhao et al., (31) performed cost-effectiveness analysis of cervical cancer screening methods, augmented by a utility analysis. The authors reported care-HPV testing every 5 years, to have the highest cost utility ratio (1,783.8 Yuan/year).

4. Discussion

This review sought to synthesise available evidence on cervical cancer screening methods and strategies to achieve optimal pre-cancerous lesion detection and thus avert cervical cancer. We thus performed a critical appraisal of economic evaluation studies of cervical cancer screening methods (n=44). All studies supported the cost-effectiveness of cervical cancer screening. In particular, our results suggest that primary HPV DNA testing strategies are likely to be cost-effective in several settings. VIA may be cost-effective in some settings, including rural areas, but not others. Similarly, cost-utility findings comparing Cytology and VIA associated VIA with higher utility. These findings echo those reported in a systematic review by Mezei et al. (25) who concluded that HPV testing and VIA are the most cost-effective screening methods in LMICs. Pap testing is less frequent as a dominant method, but also cost-effective in the context of co-testing and triaging. Our results also suggest that cervical cancer screening modalities are most effective when applied within a broader context of treatment and intervention. This would include consideration of the health economics of cervical cancer, in addition to evidence for the clinical effectiveness of different established modalities. Our review further suggests that sample collection, screening sequence, algorithms, and coverage are important.

One factor thought to influence cost-effectiveness of cervical cancer screening modalities is sample collection. Mezei et al. (32) compared self-collection followed by clinic-based VIA triage to clinic-based collection and triage in HPV-positive females in Uganda. Reduction in cervical cancer incidence and ICERs (USD/YLS) were used as measures of cost-effectiveness. Use of Monte Carlo modelling allowed the authors to show that self-collection was more cost-effective than clinic-based VIA triage based ICER outcomes. Using cytology-based screening as a comparator, Vassilakos et al (33) also reported that offering HPV self-testing is more cost-effective and associated with a reduction in cervical cancer cases and related deaths. A critical gain that both authors correlate to HPV self-testing is increased population coverage.

The method sequence could also affect cervical cancer screening cost-effectiveness. Jin et al. (34) compared the three screening methods for cervical cancer of interest in this review and found that these differed in their accuracies of detection. Co-testing was identified as more accurate, but less cost-effective. These findings echo those of Campos et al. (35) where the authors compared

different methods and interventions in their lifetime risk reduction and ICERS (USD/YLS). These measures found HPV testing with intervention to be more cost-effective compared to cytology-based strategies. Using the Nicaraguan cost-effectiveness threshold (GDP per capita of US\$2090) HPV-cryotherapy remained comparatively cost-effective, with an ICER of US\$320/YLS (35).

Several studies included in this review underscored the importance of screening coverage. In Lebanon, results from a model-based cost-effectiveness analysis indicated that using cytology as a screening modality with a shift from the current 20% coverage to at least 50% would reduce cervical cancer incidence considerably (36). More gains would be achieved if HPV-testing was used as a screening modality at 50% coverage: resulting in a 23.4% cervical cancer incidence reduction (36). Modulating coverage for different strategies (50-80%) tend to favour the cost-effectiveness of HPV-based screening strategies (36)

Our review had several limitations. First, it was difficult to account for uncertainty associated with heterogeneity and model structure across studies, meaning that internal or external model-consistency could not be guaranteed. Several model-based studies also used the same model, e.g. Campos et al. (37)(38)(39), and study findings were not disparate. Second, critical appraisal and data extraction were performed by one reviewer. However, this limitation was offset by critical appraisal and extracted data being assessed for inconsistencies by another independent reviewer. Given the significant heterogeneity of studies, study results could not be pooled and meta-analysed, a limitation common in economic evaluation systematic reviews. This limitation underscores the need to further develop and standardize economic reporting globally. An interim measure which researchers can apply is sub-set group analysis. In other words, researchers should aim to pool and compare studies similar in setting, participants, and outcomes.

5. Conclusions

In conclusion, our review supports the general cost-effectiveness of HPV testing and VIA used to screen for cervical cancer. Compared to HPV testing and VIA, cytology testing is least cost-effective. However, researchers should keep in mind that health economic reviews are not intended to provide conclusive recommendations for routine practice, but rather to guide policy makers in developing optimized strategies for testing and intervention (26). A combined approach might also prove feasible, and clinicians might need to consider the order in which screening is performed in order to maximize cost-effectiveness. Furthermore, studies show that a large body of models and simulations targeted toward cervical cancer screening evaluation exist. Countries intending to introduce more relevant and improved cancer strategies can leverage on the existing body of knowledge by learning from documented best practices.

Future studies would do well to explore the economic evaluation of cervical cancer screening in relation to the test performance of screening modalities. Furthermore, parameters such as the order of screening methods, and its relationship to the screening intervention, screening coverage, screening modality, and the number of screening visits, could have important implications for care. Further research would do well to determine what treatment options are associated with ideal clinical and economic value. The ultimate success of cervical cancer screening and treatment could depend on a broader perspective in deciding which strategy is most appropriate for the individual patient and context.

List Of Abbreviations

ASMR Age standardised mortality rates

BIA Budget Impact Analysis

CBA Cost-Benefit Analysis

CC Cost Consequence

CEA Cost-Effectiveness Analysis

CIN2+ Cervical Intraepithelial Neoplasia

CUA Cost Utility Analysis

GDP Gross Domestic Product

HEED Health Economic Evaluation Database
HERC Health Economics Resource Center
HIV Human Immunodeficiency Virus
HPV Human Papilloma Virus
HPV DNA Human Papilloma Virus Deoxyribonucleic Acid
ICER Incremental Cost-Effectiveness Ratio
JBI Joanna Briggs Institute
JBI DRM Joanna Briggs Institute Dominance Ranking Matrix
LEEP Loop Electrical Excision Procedure
NH EED National Health Economic Evaluation Database
Pap smear Papanicolaou Smear
PEPFAR President's Emergency Plan for AIDS Relief
VIA Visual Inspection with Acetic Acid
WHO World Health Organization

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

Competing interests

There is no conflict of interest in this project.

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Authors' contributions

TS searched and downloaded articles using the team-approved search strategy. LN independently screened articles and abstracts. TS appraised study methodological quality, extracted and analysed data. LN was a major contributor in manuscript conceptualization and writing. All authors read and approved the final manuscript.

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Figures

	Questions
1	Is there a well-defined question?
2	Is there comprehensive description of alternatives?
3	Are all important and relevant costs and outcomes for each alternative identified?
4	Has clinical effectiveness been established?
5	Are costs and outcomes measured accurately?
6	Are costs and outcomes valued credibly?
7	Are costs and outcomes adjusted for differential timing?
8	Is there an incremental analysis of costs and consequences?
9	Were sensitivity analyses conducted to investigate uncertainty in estimates of cost or consequence?
10	Do study results include all issues of concern to users?
11	Are the results generalizable to the setting of interest in the review?

Figure 1

JBI standardized critical appraisal instrument and Drummond's checklist

Model Element	Present	Absent	Unclear
Statement of decision problem/objective			
Statement of scope/perspective			
Rational for structure			
Structural assumptions			
Strategies/Comparators			
Model type			
Time horizon			
Disease states or pathways			
Cycle length			
Data identification			
Data modelling			
Baseline data			
Treatment effects			
Costs			
Quality of life weights			
Data incorporation			
Assessment of uncertainty			
Methodological uncertainty			
Structural uncertainty			
Heterogeneity uncertainty			
Parameter uncertainty			
Internal consistency			
External consistency			

Figure 2

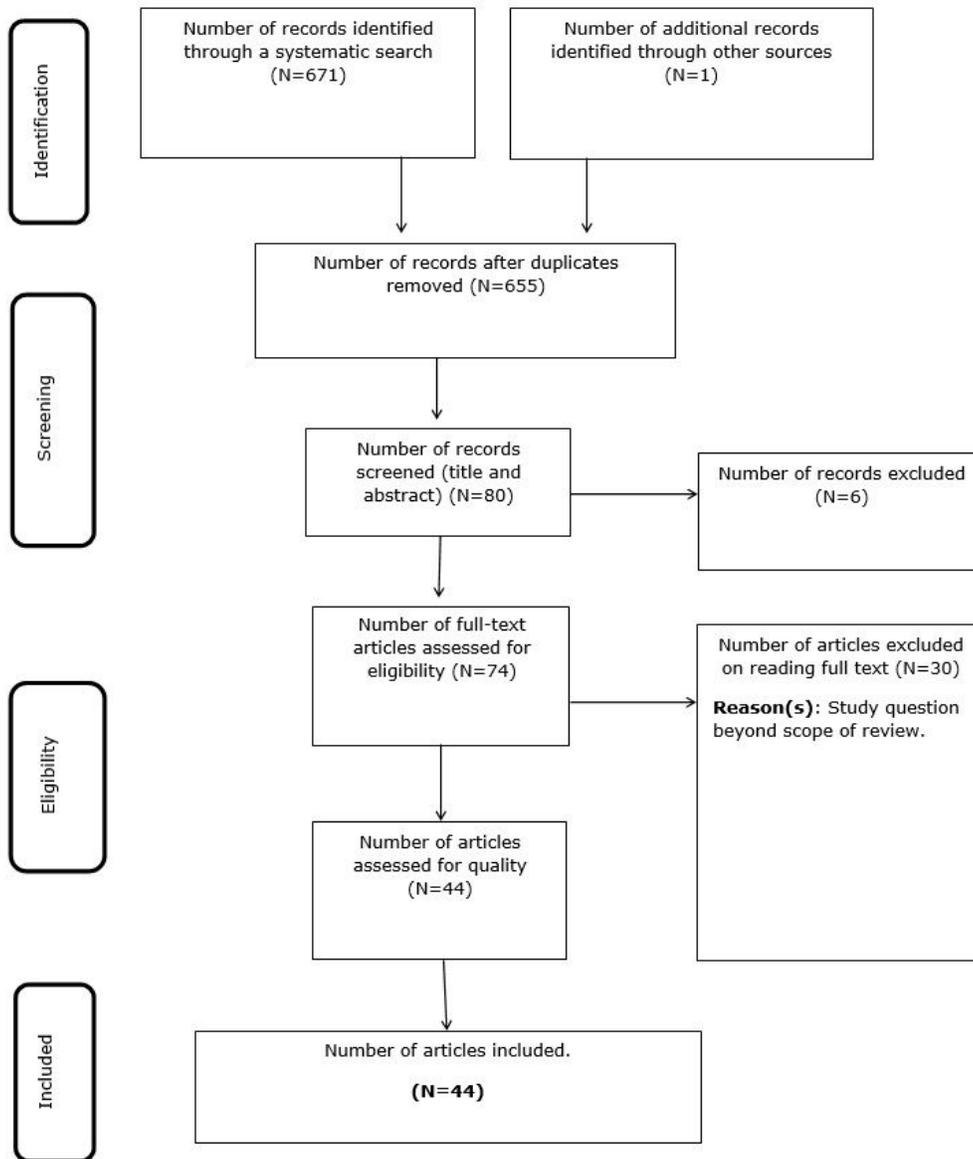


Figure 3

PRISMA scheme showing selection of studies for review (n=44)

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