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CLINICAL ARTICLE

Estimating the costs of cervical cancer screening in high-burden Sub-Saharan African countries

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ABSTRACT

Objective: To estimate the capital investment and recurrent costs of national cervical cancer screening and precancer treatment programs in 23 high-incidence countries in Sub-Saharan Africa in order to provide estimates of the investment required to tackle the burden of cervical cancer in this region. These 23 countries account for 64% of the annual cervical cancer deaths in this region. *Methods:* Secondary data were used to estimate the financial costs of equipment purchases and economic costs of screening and treating eligible women over a 10-year period. Screening would be by visual inspection with acetic acid and treatment by cryotherapy or loop electrosurgical excision procedure. *Results:* Approximately US $59 million would be required to purchase treatment equipment if cryotherapy were placed at every screening facility. Approximately 20 million women would be screened over 10 years. Cost per woman screened in a screen-and-treat program was either US $3.33 or US $7.31, and cost per woman treated was either US $38 or US $71 depending on the location of cryotherapy equipment. *Conclusion:* It would take less than US $10 per woman screened to significantly decrease the cervical cancer deaths that will occur in Sub-Saharan Africa over the next 10 years.

1. Introduction

Cervical cancer is the leading cause of cancer death for women in Sub-Saharan Africa, with approximately 50 000 women dying from it each year and 64% of these deaths occurring in 23 countries [1]. During a 10-year period, this means that approximately 320 000 women will die. This high burden of disease is largely attributable to the lack of cervical cancer screening programs, as evidenced by low incidence and burden in high-resource countries that have established screening programs [2–4]. Screening enables detection of precancer that nearly always can be eliminated by treatment, preventing the development of cancer. While HPV vaccination is an important part of a comprehensive cervical cancer prevention program, the present paper focuses on screening and the benefits that can be expected from it in the next decade.

Screening using visual inspection with acetic acid (VIA) has been shown to be an effective method for low-resource settings, and VIA is more feasible operationally than cytology-based screening [4,5]. VIA can be performed at health centers with limited supplies and has the advantage that results are available immediately, enabling the option of single-visit screening and treatment at the same facility or immediate counseling and referral for treatment.

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Several studies and pilot projects have been undertaken in Africa, either to show feasibility or to demonstrate a program of screening for cervical cancer [4,6–9], but none of the Sub-Saharan African countries has successfully scaled up a national cervical cancer screening program for all eligible women. Some countries, such as Ethiopia, Tanzania, and Zambia, have cervical cancer screening programs for HIV-positive women, while others, such as Kenya and Uganda, have developed strategic plans for national screening and control and are slowly phasing in services.

Cost is an important factor to consider when deciding to scale up services. The objective of the present analysis was to estimate the financial cost of equipment purchases and economic costs of national screening and treatment programs for cervical cancer in the Sub-Saharan African countries that have a high rate of cervical cancer, defined here as an age-standardized incidence rate greater than or equal to 30 cases per 100 000 women. The aim was to provide preliminary estimates of some of the costs of tackling the cervical cancer burden in Africa.

2. Materials and methods

The GLOBOCAN database [1] was used to identify the 23 countries that have a cervical cancer age-standardized incidence rate greater than or equal to 30 per 100 000 women. This includes approximately 34% of the population of women aged 30–49 years in the region and nearly 65% of the cervical cancer deaths.

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The financial and economic costs were estimated for a hypothetical screening and treatment program, where VIA would be used for screening and precancer treatment would be by cryotherapy or, when cryotherapy was not suitable, loop electrosurgical excision procedure (LEEP). (Financial costs capture only actual expenditures associated with a program, while economic costs value all resources used). It was assumed that screening would occur at the lowest level of the health system, and LEEP would be provided only at tertiary level referral facilities, such as regional hospitals. Two scenarios were considered for treatment by cryotherapy: (1) a single-visit approach, which implies that cryotherapy would be available at all facilities offering screening; and (2) a two-visit approach assuming that cryotherapy would occur only at the district level (the level above the lowest level). The costs were estimated for a screening program that would target women aged 30–39 years and used 2010 population data [10] to estimate the number of women eligible for screening in each country. The reported population was adjusted to 2013 levels using population annual growth rates [11]. It was assumed that the same number of women would be screened every year and each woman would be screened once during a 10-year time period.

Further assumptions regarding the numbers of women screened and treated are presented in Table 1. Note that it is assumed that all women with positive screen results will be treated either with cryotherapy or LEEP, implying that no women in this 30–39-year-old cohort would have cancer or lesions requiring other treatment methods.

An Excel-based model was used for the analysis. To begin, the financial cost of procuring cryotherapy and LEEP equipment was estimated, assuming that no equipment was currently available. For cryotherapy equipment, the cost of the units was included (approximately US $1100 each), and for LEEP, the LEEP machine (approximately US $5200 each), smoke evacuator (US $2000 each), and colposcope (US $3200 each) were included. Equipment prices were obtained from procurement documents for the Screening Technologies to Advance Rapid Testing for Cervical Cancer Prevention–Utility and Program Planning (START-UP) demonstration study in Uganda [12]. The financial cost of other (lower-priced) equipment, such as speculums, or international and local shipping costs or customs duties were not included, since these costs vary greatly by country.

The economic costs were then estimated, for which the main categories were supplies, clinical staff, and annual costs of equipment. All costs were reported in 2012 US dollars, and future expenditures were not discounted.

Data from an unpublished study conducted under the START-UP project were used to inform the estimates of the costs of supplies per woman for each screening and treatment procedure and it was assumed that these costs would not vary by country (Table 1). The same costing study was used as the source of data on the average number of minutes spent per woman for each screening and treatment procedure, and it was assumed that those costs would not vary by country. Country-specific salary data from comprehensive Multi-Year Plans (cMYP) [13] were used to estimate cost per minute of staff time, after adjusting salaries to 2012 US dollars using inflation rates on salaries reported in the cMYP. No ethics approval was sought for this study as it uses only secondary data. However, the unpublished cost study was submitted to the PATH Research Determination Committee and deemed non-human subjects research and did not need to be reviewed by an ethics committee. Informed consent was not needed for the cost study because only study staff were interviewed, not the women receiving services.

Total costs of screening supplies were estimated by multiplying the cost of supplies per woman by the number of women screened. Total clinical staff costs were estimated as the product of the number of minutes spent per woman, the country-specific clinical staff cost per minute, and the number of women screened. Similar methods were used to estimate total costs of supplies and clinical staff costs for each treatment method, multiplying by the number of women treated.

The economic costs of equipment were also estimated, which included the cryotherapy and LEEP equipment as well as speculums, basins, and examination tables. The study assumed a 10-year useful life for equipment and a 3% discount rate to determine the annualization factor, and annualized equipment costs were estimated by dividing the price of each type of equipment by the annualization factor. Total annual economic costs for equipment were estimated by multiplying the annualized cost for each equipment unit, the assumed quantity of equipment per facility, and the number of facilities at that level of the health system. The number of facilities at each level of the health system was obtained from each country's cMYP.

Table 1
Key assumptions and cost estimates for cervical cancer screening and treatment in Sub-Saharan Africa.

Variable	Value	Source and comments
Proportion of eligible women presenting for screening	80%	Assumed
Proportion of women having an abnormal VIA screening result	11.5%	WHO [4]
Proportion of women eligible for treatment with cryotherapy	87.7%	WHO [4]
Proportion of eligible women receiving cryotherapy when cryotherapy is offered at the health center	95%	Assumed
Proportion of eligible women receiving cryotherapy when cryotherapy is offered at the district	80.8%	Assumed a 15% loss to follow up with referral to the district
Proportion of women eligible for treatment with LEEP	12.3%	Assumed; this implies that all women are effectively treated with cryotherapy or LEEP
Proportion of eligible women treated with LEEP	50%	Assumes 50% loss to follow up with referral to tertiary level care
Costs of supplies for VIA	US $0.32	START-UP project – Uganda (unpublished study)
Costs of supplies for cryotherapy	US $1.99	START-UP project - Uganda
Costs of supplies for LEEP	US $31.48	START-UP project - Uganda
Amount of time to perform VIA screening	10 minutes	START-UP project - Uganda
Staff time per woman to perform cryotherapy procedure	25 minutes	START-UP project - Uganda
Amount of time to perform LEEP procedure	25 minutes	START-UP project – Uganda
Salaries for medical personnel	Varied by country	WHO Comprehensive multi-year plans [14]
Annual economic costs of equipment used for VIA (costs per facility)	US $40	START-UP project – Uganda
Annual economic cost for equipment used for cryotherapy when at the health post (costs per facility)	US $167	START-UP project – Uganda Assumed that there is one cryotherapy machine per facility
Annual economic cost for equipment used for cryotherapy when at the district (costs per facility)	US $309	START-UP project – Uganda Assumed that there are two cryotherapy machines per facility
Annual economic cost for equipment used for LEEP (costs per facility)	US $1300	START-UP project – Uganda
Number of health facilities at each level	Varied by country	WHO Comprehensive multi-year plans [14]

Abbreviations: VIA, visual inspection with acetic acid; LEEP, loop electrosurgical excision procedure; WHO, World Health Organization.

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Total economic costs were estimated as follows:

Total screening costs = costs for screening supplies + costs for clinical staff for screening services + annual economic costs of the screening equipment
Total treatment costs = costs for treatment supplies + costs for clinical staff for treatment services + annual economic costs of the treatment equipment
Total program costs = total screening costs + total treatment costs

The cost per woman screened and the cost per woman treated were estimated as follows:

Cost per woman screened = total program costs / number of women screened
Cost per woman treated = total program costs / number of women treated

3. Results

Table 2 presents the financial costs of procuring the cryotherapy and LEEP equipment in the 23 countries. If cryotherapy is performed at all facilities where screening occurs, the financial costs for equipment are approximately US $59 million, with 94% of the cost for cryotherapy equipment and 6% for LEEP equipment. In the scenario with cryotherapy only at the district level, the costs were estimated at US $8.2 million, with 58% of the expenditure for cryotherapy equipment.

Table 3 presents the estimated total number of women screened and treated and the total economic costs for the program over the 10-year period. It was estimated that approximately 24 million women aged 30−39 years would be eligible for screening, and 20 million of them would be screened. An estimated 2.2 million would have abnormal VIA screening results, and between 1.6 and 1.9 million would be treated with cryotherapy, while approximately 140 000 would be treated with LEEP.

The economic costs of the resources used for screening in the 23 high-burden African countries would be approximately US $41 million over the 10-year period (Table 3). In the single-visit scenario, total treatment costs with cryotherapy for the cohort were estimated at US $92 million, and under the two-visit scenario, the estimate was about US $15 million. When cryotherapy is provided at all health facilities that offer screening, the cryotherapy treatment costs are the largest share of economic costs (65%); however, when cryotherapy is provided only at district levels, screening costs become the largest share of costs (63%). Average costs per woman screened and per woman treated are considerably higher for the single-visit treatment scenario, estimated at US $7.31 and US $70.91 respectively, than for the two-visit scenario, at US $3.33 and US $37.58 respectively. In both cases, LEEP is provided at the tertiary level of the health system when needed.

Supplementary Table S1 provides the estimated number of women served in each of the 23 countries and total costs for the cohorts, which range from US $191 000 (for Comoros) to US $61 million (for Nigeria) for the single treatment scenario, with population size as the main driver of total costs. Supplementary Figs. S1 and S2 show the proportion of costs for each component (screening, cryotherapy, and LEEP) in each country under the two scenarios. Total cost per woman treated ranged from US $31 (for Guinea) to US $93 (for Zambia) for the single-visit scenario. Equipment costs per woman are higher for facilities serving fewer women resulting in higher costs per woman treated. Fig. 1 shows estimated treatment costs per woman when cryotherapy is provided at each health center, where it is estimated the equipment would be used to treat at most 12 women each year.

When cryotherapy is offered only at district-level hospitals, the estimated cost per woman treated in the 23 countries ranged from US $22 (for Guinea) to US $58 (for Ghana) (Supplementary Table S2). In this scenario, it was estimated that cryotherapy would be used to treat between 15 and 192 women per year, spreading the equipment costs over a larger population compared with the single-visit scenario (Fig. 2).

Table 2
Financial costs for equipment required for cryotherapy and LEEP procedures in 23 selected countries in Sub-Saharan Africa.

	Screening and cryotherapy at health centers and LEEP at regional hospitals	Screening at health centers, cryotherapy at district, and LEEP at regional hospitals
Cryotherapy equipment costs	US $55,099,057	US $4,782,900
LEEP equipment costs	US $3,425,155	US $3,425,155
Total upfront financial costs	US $58,524,212	US $8,208,055

Table 3
Number of women screened and treated in 23 selected countries in Sub-Saharan Africa and total economic costs for the 10-year period.

	Screening and cryotherapy at health centers and LEEP at regional hospitals (cryotherapy single-visit scenario)	Screening at health centers, cryotherapy at districts and LEEP at regional hospitals (cryotherapy two-visit scenario)
Number of women served		
Number of women screened	19 450 750	
Number of women treated with cryotherapy	1 866 690	1 586 600
Number of women treated with LEEP	137,870	
Economic costs		
Screening costs	US $40,595,721	
Treatment costs (cryotherapy)	US $92,449,825	US $15,106,166
Treatment costs (LEEP)	US $9,104,480	US $9,104,480
Total costs	US $142,150,026	US $64,806,367
Cost per woman screened	US $7.31	US $3.33
Cost per woman treated	US $70.91	US $37.58

4. Discussion

This paper presents the financial and economic costs of screening women aged 30−39 years once in a decade using VIA and treating screen-positive women with either cryotherapy or LEEP for 23 Sub-Saharan African countries. A literature search found one analysis that estimated similar scale-up costs for Ghana [14].

Variability in the estimated average cost per woman screened or treated across countries can be explained by several factors. First, when the number of women served per health facility is relatively low (in either sparsely populated areas or densely populated areas with multiple facilities), the resulting economic cost for equipment per woman is higher when compared with the costs in a country where each health facility serves a larger population. Second, differences in salaries for medical personnel across countries may account for some of the variability.

In assessing costs for two different scenarios for location of cryotherapy services, it was found that the costs per woman treated were much higher when cryotherapy is provided at all facilities where screening occurs. There is a tradeoff between higher cost with increased accessibility of treatment services versus lower cost and reduced accessibility, and policymakers will have to decide what matters more as they make this decision in their programs. The key drivers of this tradeoff are: (1) travel distances between local facilities and district referral facilities; and (2) ability to overcome the reluctance of women to complete treatment, by counseling at the time of screening or by tracking those who do not go for referral treatment and persuading them to do so. This analysis can provide input data for cost-effectiveness analyses that evaluate screen and treat strategies, and the results highlight the relatively higher cost of single-visit strategies, costs that may previously have been underestimated.

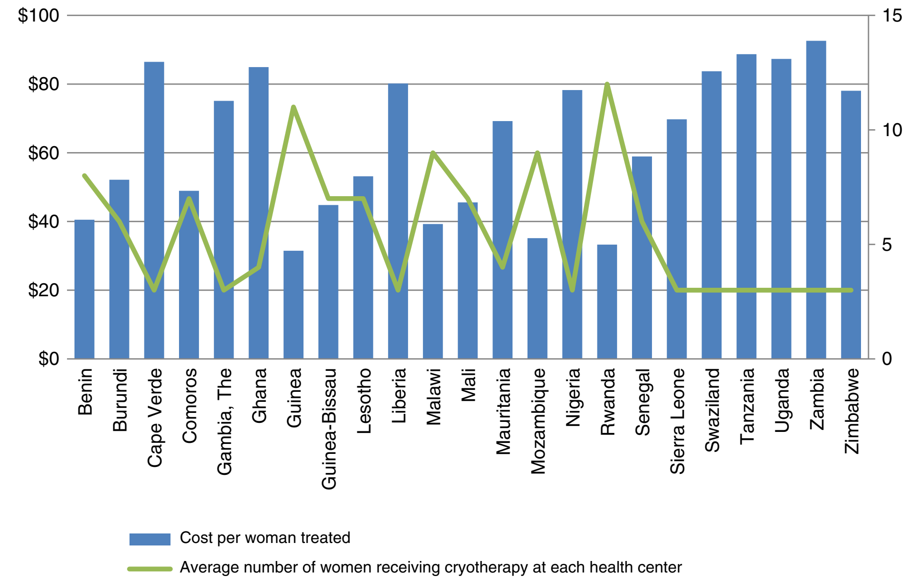

Fig. 1. Cost per woman treated and number of women treated per health center when cryotherapy is provided at all health centers offering screening.

This analysis did not account for the reduction in the number of abnormal VIA screens and related treatments that would result as a benefit of having school-aged girls immunized with the HPV vaccine [15]. The benefits of vaccination for screening will be reaped in approximately 20 years for the current cohort of school-aged girls who receive the vaccine and therefore are not relevant within the timeframe of the study, since the focus is on women who are currently aged 30—39 years.

This analysis only considered using VIA as the screening method. However, there are new HPV DNA tests available, including those that can be done with a self-collected specimen, which countries could consider using alone or in combination with VIA or other molecular tests in order to triage the women with positive HPV results. This approach could greatly alter the cost and effectiveness of screening, but the tests are not yet widely available and the analysis is beyond the scope of this study.

There are several limitations of this analysis. Simplifying assumptions were made, such as assuming the same unit costs for supplies and equipment across countries, as country-specific unit costs were not available. However, since the cost of supplies is low, this should not impact the estimates significantly. Most of the countries will need to import equipment from a small selection of manufacturers and, since the equipment costs do not include the costs of shipping or customs duties, it was assumed that the equipment purchase costs will be about the same across countries. Also, the costs of smaller equipment such as speculums were not included in the financial cost estimates. Second, the study assumed no variability in the proportion of women with abnormal VIA screens or the proportion of women eligible for cryotherapy across countries because data for all countries were not available in the sample. The treatment costs for each country will be lower if the percentage of women screening positive is lower than the percentage used in this analysis (11.5%) and vice versa. The study also assumed that all women would be treated with cryotherapy or LEEP, and therefore the costs for treatment of invasive cancer were not included. Third, the costs of hiring new staff if this is necessary were not included. Fourth, the study did not include the start-up costs for planning, implementation activities (such as training medical personnel to perform VIA and cryotherapy), or social mobilization, communication, supervision of medical personnel, monitoring and evaluation of the program, following up women with positive screen results to encourage them to seek treatment, international and local shipping costs for equipment, or other costs associated with establishing or managing the screening and treatment program. These costs are likely to be a

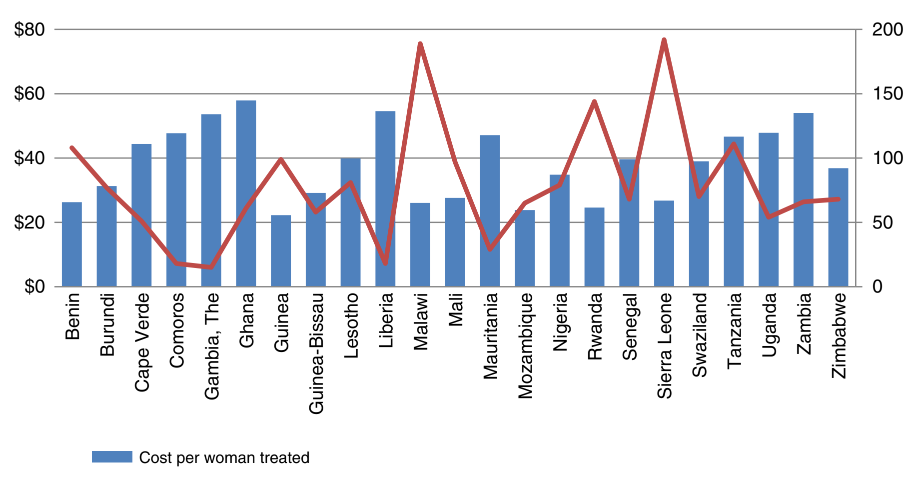

Fig. 2. Cost per woman treated and number of women treated per health center when cryotherapy is provided only at the district level.

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large share of any successful program, although many of the non-training costs may be shared with other health services. Because of the third and fourth limitations, the costs of the program have been underestimated. However, most of the treatment equipment purchased has a useful life longer than 10 years, so the model may overestimate the cost of treatment.

In conclusion, this is one of the first attempts to estimate the global costs of a cervical cancer screening program, starting in the countries with the highest cervical cancer burden in Sub-Saharan Africa. This study estimates that the economic costs for screening and treatment would be approximately US $65 million to US $142 million (depending on the level of the health system where cryotherapy is provided) to serve about 20 million women over a 10-year period. At US $3.33 to US $7.31 per woman screened (and treated when necessary), the opportunity to prevent even half of the 320 000 deaths from cervical cancer that are expected in the next 10 years in these 23 high-burden countries would seem to be a cost-effective, worthwhile investment.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ijgo.2014.02.012.

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Conflict of interest

The authors have no conflict of interest to declare.

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